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It is my great pleasure to state that we have finally achieved the goal of serial publication the journal *Surgery and Surgical Endoscopy*. The journal is an important source for the national and global progress of surgical science. However, this achievement would not have been possible without dedicated surgeons and the journal's enthusiastic editors-in-chief, and I would like to take this opportunity to congratulate them. Jan Grosek and Tomaž Jagrič have performed tremendous work during the last years, and their contribution is noteworthy.

This issue of *Surgery and Surgical Endoscopy* offers a variety of articles from Slovenia, covering a wide spectrum of benign and malignant diseases from different surgical fields, truly reflecting our preferences.

New technologies and a generation of surgeons mastering advanced minimally invasive surgery have greatly contributed to the development and growth of laparoscopic hepatic surgery. Skepticism related to technical and oncological concerns initially limited the widespread acceptance of this approach. The laparoscopic approach must not compromise the technical quality of liver resection. An important message from several consensus conferences was the need for a formal education structure and the introduction of clinical practice guidelines to direct the specialty's continued safe progression and dissemination. Considering the context, learning curves have received increased attention. Arpad Ivanecz and his colleagues investigated a single surgeon and institution learning curve for laparoscopic liver resection during a 12-year period. It is not limited to a single procedure, and the complexity of operations varies from wedge resections to major hepatectomies. This series demonstrates the parallel development of procedures and indications, illustrating the significance of the learning process in clinical practice. The learning curve resembles a true model, in which alternating periods of progression and regression occurred until mastery was achieved. Younger surgeons could benefit from an individual's experience of performing laparoscopic liver surgery along the learning curve and applying difficulty scores.

The first laparoscopy-assisted gastrectomy for gastric cancer in the world was performed in the early 1990s, and

30 years have passed since then. In the beginning, laparoscopy itself was a coarse procedure, and there were no specialized surgical instruments because repeated trial and error occurred. However, surgeons were impressed with how remarkable less-invasive surgery was. Later, by comparing laparoscopic gastrectomy with traditional open surgery, many surgeons realized that laparoscopy-assisted gastrectomy would contribute to improving the quality of life for patients after surgery, and the procedure started to spread widely. Two articles offer different perspectives on the implementation of minimally invasive radical gastrectomy with D2 lymph node dissection for gastric cancer. In an interesting case report, Nenad **Čubrić** and Tomaž Jagrič highlight the importance of identifying the presence of anatomical variants of the left hepatic artery during gastrectomy. They reexamined the age-old question: to ligate or preserve it? Ligation could potentially lead to serious complications such as liver abscess, liver failure, or even death. However, they reported no major morbidity after ligation of a variant left hepatic artery. In addition, the second article by Jagrič and his colleagues from the Department of Abdominal Surgery, Department of Radiology, and Faculty of Electrical Engineering and Computer Science introduces a study protocol to assess the reliability of using 3D models of organs from preoperative images. In laparoscopic gastric surgery, a surgeon works on a small operative field with limited visibility without the sense of touch. To compensate for these disadvantages, they supplement laparoscopy with augmented reality. However, is augmented reality–guided surgery reproducible at every center? Are these new 3D technologies cost-effective? This study will probably stimulate increased interest in this topic.

In the past decades, laparoscopy has entered and conquered all bastions of open surgery. It is the first time in the history of surgery that such drastic and sweeping changes have occurred in such a short period of time. It is now inconceivable for any surgical discipline not to offer the patient a minimally invasive approach. Furthermore, laparoscopic surgery has become a major component of training surgical residents. The era when surgeons and residents had to learn basic and advanced laparoscopic

Editorial

techniques over a weekend course is a thing of the past. It is now expected that surgeons in training will be exposed to laparoscopy throughout their residency or specialized fellowship programs. Laparoscopic inguinal hernia repair has become established at many hospitals in Slovenia. However, Mihhail Kajumov has demonstrated that no standardized curriculum exists for general surgery residents for learning laparoscopic hernia repair in Slovenia. I recommend this excellent article for potential reading because it represents an evident call for a standardized, step-by-step learning approach. I found it interesting to learn about the strong support for laparoscopic inguinal hernia repair at Izola General Hospital. The most recent data from this hospital showed that 57% of inguinal hernia repairs are performed laparoscopically. This is a great achievement, especially when realizing that laparoscopic inguinal hernia repair accounts for only 14% of inguinal hernia surgery in Slovenia.

Another interesting case report can be found in the journal. Melisa Lazarevič and her colleagues describe intestinal obstruction due to ileocolonic intussusception in adults. This is a condition in which a proximal portion of the intestine folds into a more distant part, obstructing its lumen. This condition is more frequent in children, where it is usually idiopathic, whereas adult intussusception is usually due to an intestinal mass, which serves as a lead point. The authors describe two cases of intussusception in adults caused by benign and malignant tumors, respectively. Both patients were operated on successfully with no morbidity and mortality.

I read the article presented by Kosta Cerović and Simon Hawlina with great interest. Robotic surgery is gaining ground around the world, and Slovenia is no exception. The more accurate and precise movements provided by robotic instruments, coupled with greater dexterity, facilitate complex resections and procedures involving reconstructions. The Department of Urology at the Ljubljana Medical Center started using a robotic platform in June 2018 and performed 100 robot-assisted laparoscopic partial nephrectomies by August 2021. The total number of robotic urological procedures, including radical prostatectomies, is even higher. They highlight excellent functional and oncological results when the procedure is performed by an experienced surgeon at a high-volume center. Minimally invasive surgery has become the gold standard for kidney surgery. However, can robot-assisted laparoscopic partial nephrectomy replace minimally invasive surgery without a robot? Presumably yes, but do all the departments in Slovenia have a robot? This is a yes–no question. Do all residents of Slovenia have the opportunity to undergo robotic surgery? Another closed

question. Should we centralize all these procedures? In my opinion, having a robot means the procedure can be performed by less-experienced surgeons achieving the same functional and oncologic results. If a robot is not available, surgeons still need to be more proficient and experienced in the surgical technique lacking the newest surgical technology. With the development of robotic surgery, robot-assisted laparoscopic partial nephrectomy is becoming a state-of-the-art choice for partial nephrectomy. Purchasing a robot should be a priority to obtain the most recent surgical technology to support the best surgical technique attainable for every surgeon and patient.

Finally, Jurij Aleš Košir and his colleagues present a study protocol to facilitate an understanding of the role of malnutrition in adhesive small bowel obstruction. They plan to analyze computer tomography images at the L3 level to measure skeletal muscle area and muscle attenuation to determine the extent of sarcopenia and myosteatosis, respectively. If the patients are operated on, they will grade the extent of adhesions intraoperatively using a peritoneal adhesion index protocol. After the operation they will follow the patients to grade postoperative complications. A better understanding of the role of malnutrition will help us know whether we should consider non-operative management or operate on these patents earlier. Because adhesive small bowel obstruction is the most common form of mechanical bowel obstruction, this study will presumably stimulate increased interest within the expert community.

In conclusion, I would like to share just one more consideration. Before starting to write this editorial, I promised myself I would not discuss the COVID-19 pandemic. However, it is impossible to avoid the impact of this exasperating disease on the surgical community all around the world. Many residents and younger surgeons have been displaced to COVID-19 departments, which has interrupted their surgical careers and learning. Dealing with the COVID-19 pandemic is not surgery. During these times there have been no conferences, surgical meetings, or workshops. Webinars cannot replace personal communication, and computer-screen dinners are not closing ceremonies. Has surgical progress stopped? Have these years been lost? Not for everyone. We have witnessed the excellent contributions to this journal.

Enjoy reading the articles in this issue!

Assist. Prof. ***Arpad Ivanecz***

Editorial

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The Evolution of Laparoscopic Liver Resection: A Single-Institution Experience with a Time-Trend Analysis

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Key words

laparoscopy, hepatectomy, learning curve, morbidity, intraoperative complication, postoperative complication

Research Article

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Abstract

Background. This study assesses the development of laparoscopic liver resection at a tertiary referral center and its learning curve.

Methods. A retrospective review of a prospectively maintained database of liver resections was conducted. A total of 136 patients undergoing pure laparoscopic liver resection between April 2008 and June 2019 were analyzed. Laparoscopic liver resections were divided into four consecutive groups of 34 patients to compare their characteristics. A major operative event was defined as operation time longer than 300 min, perioperative blood loss more than 500 ml, or the presence of major postoperative complications.

Results. Out of 774 patients, 136 (17.6%) underwent laparoscopic liver resection. The proportion of laparoscopic liver resections increased over time (7.6%, 22.8%, 37.0%, and 39.0%). A statistically significant growing trend among the four groups was observed for higher patient age, ASA scores ≥ 3, previous laparotomy, malignancy of lesions, and posterosuperior liver segments ($p < 0.05$). An increasing trend of complex resection was noted ($p < 0.05$). The rates of a major operative event among groups increased statistically insignificantly (11.8%, 26.5%, 29.4%, 35.3%; $p = 0.123$). The distribution analysis confirmed these results. The conversion rate was 12.5%. The major morbidity rate was 25.7% and the mortality rate 1.5%. Logistic regression analysis showed that a major operative event was statistically significantly associated with ASA score, liver cirrhosis, deep location of the lesion within the liver, and tumor size > 5 cm ($p < 0.05$).

Conclusion. A trend of increasing major operative event rates appears to be parallel with the intricacy of the cases. The interchanging pattern of a major operative event indicates an ongoing learning process for more vulnerable patients and complex resections.

Introduction

Interest in laparoscopic liver resection (LLR) has grown since the publication of the International Louisville Statement on laparoscopic liver surgery (1). Since then, the number of LLRs performed worldwide has increased exponentially (2).

The laparoscopic approach must not compromise the technical quality of the liver resection. An important message from the second Morioka consensus conference in 2014 was the need for a formal education structure for those interested in performing LLR (3). The need for organizing LLR was achieved by the establishment of the International Laparoscopic Liver Society in 2016 (4). The third consensus meeting in Southampton, in 2017, produced a set of clinical practice guidelines to direct the specialty's continued safe progression and dissemination (5).

In this context, learning curves have received increased attention (6–19). The idealized model of a learning curve has been described, demonstrating continuous improvement (6). Recently, the learning curve has been reported to resemble a true model, in which alternating periods of progression and regression occurred until mastery was achieved (14).

This study is based on 12-year single-center experience. It presents the development of laparoscopic liver resection (LLR) at a tertiary referral center and assesses its learning curve.

Methods

Patients

Study subjects were identified from a prospectively maintained database of patients that underwent liver resections at the Department of Abdominal and General Surgery, Maribor Medical Center, Slovenia. This institution is a tertiary referral center specializing in hepato-pancreato-biliary surgery, where LLR was first performed in April 2008. The study included all patients in whom a pure laparoscopic liver procedure was initiated (intention-to-treat analysis) until June 30th, 2019. For this study, patients that underwent laparoscopic cyst fenestration, liver biopsies, and radiofrequency ablation were excluded.

Routine diagnostic workup consisted of blood work, chest radiography, abdominal CT scans with contrast enhancement, or liver-specific contrast MRI. Performance status was defined according to the American Society of Anesthesiologists (ASA). The patients' preoperative liver function was assessed according to the Child–Pugh classification (20). The tumor location was defined as anterolateral in segments 2, 3, 4b, 5, and 6, and posterosuperior in segments 1, 4a, 7, and 8.

All patients were considered at a multidisciplinary board meeting. The indications for LLR were the same as for the open approach. Benign lesions were resected if they were symptomatic or because of uncertain diagnosis at biopsy (1, 21). Initially, solitary and peripherally located tumors in anterolateral segments were resected. With growing experience, the laparoscopic approach was implemented regardless of tumor location. Absolute contraindications for the laparoscopic approach included the need for biliary or vascular resection and reconstruction, *en bloc* multi-organ resection, and resections for hilar cholangiocarcinoma (6).

The liver anatomy and resection terminology were based on the Brisbane 2000 Classification of the International Hepato-Pancreato-Biliary Association (22). Hepatic resections were anatomic when at least one segment was removed entirely. Hepatectomies were major when at least three adjacent segments were removed; otherwise, they were minor. In addition to this classification, technically major resections that did not meet the criteria of major anatomical resections but involved technically demanding posterosuperior segments 1, 4a, 7, and 8 were included (23–24).

Only pure LLRs were performed; no hand-assisted or hybrid procedures were applied. All the patients were operated on by the same surgeon (AI), who had expertise in open hepato-biliary pancreatic surgery and laparoscopic surgery but no experience with LLR before this series. The surgical technique for LLR has been extensively described by others (25) and was performed as published previously (26–28). Conversion was defined as the requirement for laparotomy at any time of the procedure, except for the extraction of the resected specimen. Histological surgical margins for malignant lesions were defined as microscopically positive (< 1 mm, R1) or negative (R0). R0 resection was defined as the complete removal of tumors with a clear microscopic margin. Postoperative

complications were defined as any deviation from the ordinary course of recovery with the need for pharmacological, surgical, radiological, or endoscopic intervention and were based on the most severe complication within 90 days of surgery. Postoperative morbidity was classified according to the Clavien–Dindo classification (29). Grades ≥ 3 represented a major complication requiring invasive intervention, the use of organ support, and fatality.

All patients gave written consent for anonymous data to be used for research purposes at the time of surgery. Patient records were anonymized and de-identified before analysis. Ethical approval for this study was obtained from the local institutional review board.

Outcomes

Two analyses were performed. The first compared the numbers and proportions of all LLRs over 12 years (April 2008 – June 2019) to depict the evolution of the practice. In the second analysis, LLRs were divided into four consecutive groups of 34 patients (Groups 1, 2, 3, and 4) to compare their characteristics. Technical details (type of resection) and established indicators of technical difficulty (conversion, transfusion, hepatic pedicle clamping, and its duration) were analyzed.

The primary endpoint of the study was to assess the development and learning curve of LLR at our institution. The study's endpoint was a major operative event (MOE), expressed as operation time longer than 300 min, perioperative blood loss greater than 500 ml, or the presence of major postoperative complication, as proposed by Lin et al. (15). The established indicators of a technical difficulty (provided above) were used as surrogate endpoints. The secondary endpoint was to analyze our factors associated with MOE.

Statistical Analysis

IBM SPSS for Windows Version 26.0 (IBM Corp., Armonk, NY, USA) was used for statistical computations. Univariable analysis for categorical variables was performed using the Fisher–Freeman–Halton test, two-tailed in all instances. The Shapiro–Wilk test assessed the normality of data of continuous variables. When the value of this was greater than 0.05, the normality of the data was confirmed. Continuous variables were analyzed using the Kruskal–Wallis test because the criteria for parametric testing were not met. The Kolmogorov–Smirnov test was performed to test the distribution of the interval across the major operative event.

The graphical time-trend analysis of MOE was performed by the following sequence in SPSS: Graphs → Compare Subgroups → Kernel Smoother histogram type; proportion 0.05. The kernel smoother displayed a smoothed density function. The entire-group and subgroup distributions were each scaled to the number of points in them.

The command Binary Logistic Regression of SPSS performed logistic regression analysis. All reasonable factors were tested one by one with MOE as the dependent variable. Those that reached statistical significance were then used in the Enter method. A bootstrap (1,000 samples, simple sampling, 95% confidence interval) was performed to enhance the model's accuracy. The equation of logistic regression was obtained. This analysis was checked for sensitivity and specificity by the receiver operating characteristic (ROC) curve. According to the results, a new threshold was set and tested with the chi-squared test.

All percentages were listed to one decimal place, and a difference with a p-value of < 0.05 was considered statistically significant.

Results

Trends in liver resection and rates of laparoscopic liver resections over 12 years

From April 2008 to June 30th, 2019, 774 patients underwent liver resection (Figure 1). The median number of liver resections per year was 66 (IQR 16), and the trend was stable ($p = 0.443$). The median rate of LLRs per year was 15% (IQR 27). Although a growing trend was observed, the difference was statistically insignificant ($p = 0.443$).

Basic Assessment of the Groups

A pure LLR was attempted in 136 (17.6%) patients. To demonstrate the evolution of the practice and the center experience, these patients were divided into four consecutive groups (Groups 1, 2, 3, and 4) of 34 consecutive cases performed in four different periods, which lasted 76, 25, 16, and 14

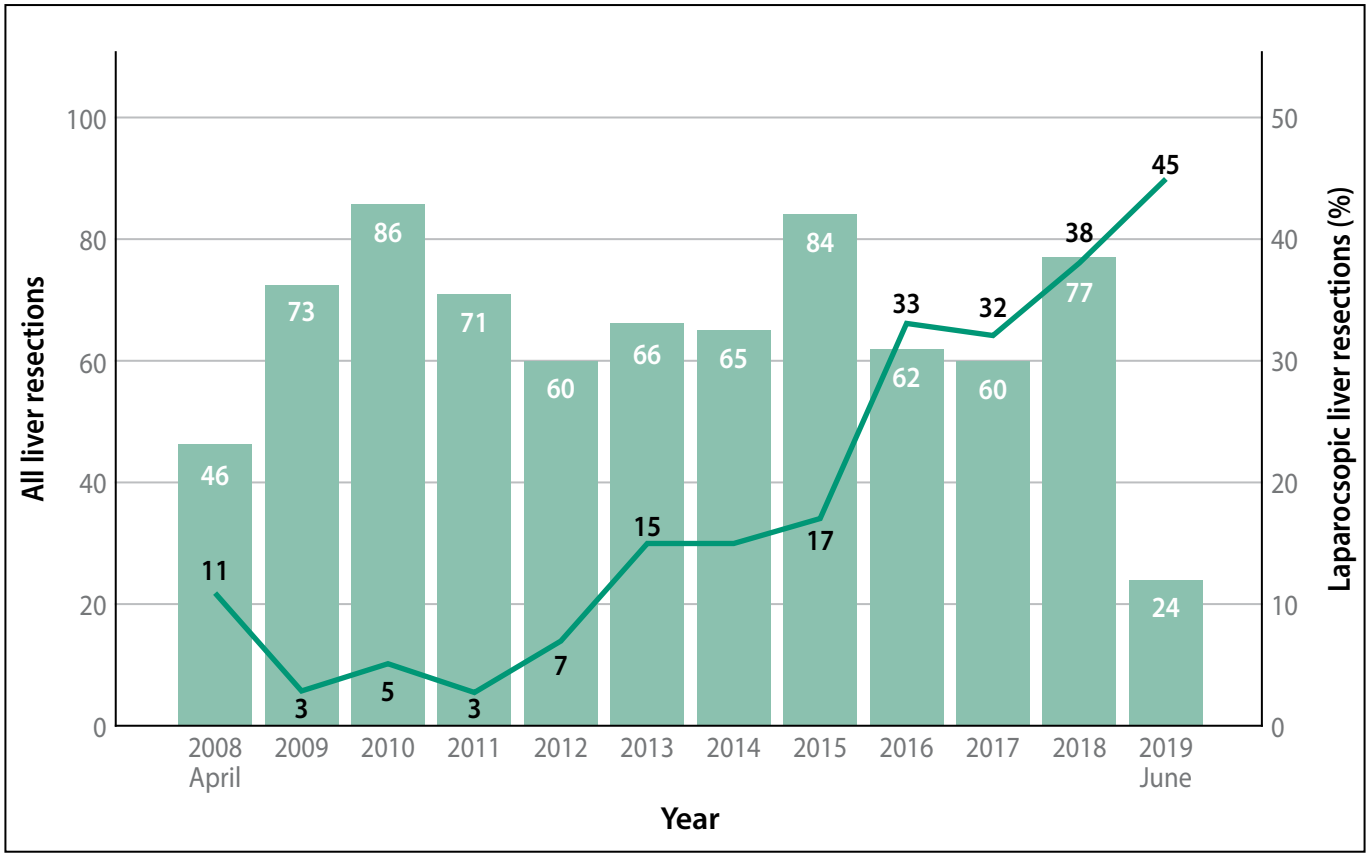


Figure 1. Annual number of liver resections and rates of laparoscopic liver resection from April 2008 until June 2019.

months, respectively. The early period (April 2008 – August 2014) represented the development of the basic technique. During the second period (September 2014 – November 2016), the application of this technique was extended to major resections and posterosuperior lesions. The third period (December 2016 – April 2018) represented a continuous application of LLR to more difficult procedures. The fourth period (May 2018 – June 2019) represents an expanded range of LLR procedures. The duration of the periods was statistically insignificant ($p = 0.392$). The rates of LLRs in consecutive periods were 7.6%, 22.8%, 37.0%, and 39.0%. The growing trend did not reach statistical significance ($p = 0.392$).

Comparison of the Groups

The demographic and clinical data of 136 patients are shown in Table 1. Age, age > 70 years, ASA score > 3, previous laparotomy, malignancy of the lesion, deep location within the liver, and posterosuperior liver segments were statistically significant among four groups ($p < 0.05$). Rates and trends are shown in Table 1.

The technical details, the outcome of the study (MOE), and its surrogates, rates, and trends among groups are shown in Table 2. Anatomic resection was performed in 78 (57.4%), anatomically major resection in 21 (15.4%), and technically major resection in 39 (28.7%) patients. These rates increased statistically significantly among groups ($p < 0.05$). MOE was present in 35 (25.7%) patients and did not differ statistically significantly among groups ($p = 0.123$).

The procedure was completed laparoscopically in 115 (87.1%) patients. Reasons for conversion to laparotomy of the remaining 17 (12.5%) patients are provided in Table 3. In these cases, the decision to proceed to conversion was not made upon life-threatening bleeding. The indications for liver resections in converted cases were malignant tumors.

The major morbidity rate was present in 18 (13.2%) patients (Table 3). The mortality rate was 1.5%, with two postoperative deaths within 90 days.

Table 1. Patient and lesion characteristics.

Variables	Total *n* = 136	Group 1 *n* = 34	Group 2 *n* = 34	Group 3 *n* = 34	Group 4 *n* = 34	*p*-value [a,b]
Male sexa	82 (60.3%)	19 (55.9%)	19 (55.9%)	24 (70.6%)	20 (58.8%)	0.552[a]
Age (years)[b]	64 (17) (20–86)	57 (17)	59 (17)	69 (12)	68 (13)	< 0.001[b]
Age > 70 years[a]	41 (30.1%)	4 (11.8%)	7 (20.6%)	15 (44.1%)	15 (44.1%)	0.004[a]
BMI (kg/m²)[b]	26.8 (5.3) (18–50)	27.2 (5.0)	25.7 (5.9)	25.5 (5.6)	27.6 (5.5)	0.616[b]
ASA score > 3[a]	42 (30.9%)	3 (8.8%)	8 (23.5%)	16 (47.1%)	15 (44.1%)	0.001[a]
Liver cirrhosis: Child–Pugh A[a]	25 (18.4%)	7 (20.6%)	7 (20.6%)	4 (11.8%)	7 (20.6%)	0.714[a]
Previous laparotomy[c]	32 (23.5%)	2 (5.9%)	6 (17.6%)	11 (32.4%)	13 (38.2%)	0.005[a]
Malignant tumor[a]	97 (71.3%)	18 (52.9%)	23 (67.6%)	26 (76.5%)	30 (88.2%)	0.011[a]
Neoadjuvant chemotherapy[a]	19 (14.0%)	5 (14.7%)	6 (17.6%)	6 (17.6%)	2 (5.9%)	0.482
Max. diameter (mm)[b]	39 (32) (10–160)	30 (33)	42 (31)	40 (24)	39 (32)	0.082[b]
Max. diameter > 50 mm[a]	44 (32.4%)	9 (26.5%)	13 (38.2%)	10 (29.4%)	12 (35.3%)	0.760[a]
Deep location within liver[a]	36 (26.5%)	4 (11.8%)	7 (20.6%)	10 (29.4%)	15 (44.1%)	0.022[a]
Posterosuperior liver segments[a]	32 (23.5%)	1 (2.9%)	8 (23.5%)	9 (26.5%)	14 (41.2%)	0.001[a]

[a] = Categorical variables, Fisher–Freeman–Halton test; [b] = Continuous variables are reported as median (IQR) (min–max); Kruskal–Wallis test; [c] = Previous laparotomy included median laparotomy or right subcostal incision. BMI = body mass index, ASA = American Society of Anesthesiologists physical status score.

Table 2. Intra- and postoperative details and outcomes.

Variables	Total *n* = 136	Group 1 *n* = 34	Group 2 *n* = 34	Group 3 *n* = 34	Group 4 *n* = 34	*p*-value[a,b]
Anatomic resection (22)[a]	78 (57.4%)	11 (32.4%)	21 (61.8%)	18 (52.9%)	28 (82.4%)	< 0.001[a]
Anatomically major resection (22)[a]	21 (15.4%)	1 (2.9%)	4 (11.8%)	7 (20.6%)	9 (26.5%)	0.030[a]
Technically major resection (23)[a]	39 (28.7%)	2 (5.9%)	11 (32.4%)	12 (35.3%)	14 (41.2%)	0.003[a]
Operation time (min)[b]	160 (90) (25–450)	135 (115)	170 (81)	170 (90)	180 (105)	0.394[b]
Blood loss (ml)[b]	120 (245) (0–2,220)	100 (150)	110 (313)	175 (0–355)	160 (237)	0.357[b]
Operation time > 300 min[a]	5 (3.7%)	2 (5.9%)	0 (0.0%)	0 (0.0%)	3 (8.8%)	0.168[a]
Blood loss > 500 m[a]	18 (13.2%)	0 (0.0%)	7 (20.6%)	6 (17.1%)	5 (14.7%)	0.028[a]
Major morbidity CD 3a–5 (29)[a]	18 (13.2%)	2 (5.9%)	3 (8.8%)	7 (20.6%)	6 (17.6%)	0.256[a]
Major operative event (15)[a,d]	35 (25.7%)	4 (11.8%)	9 (26.5%)	10 (29.4%)	12 (35.3%)	0.123[a]
Conversion[a]	17 (12.5%)	1 (2.9%)	4 (11.8%)	6 (17.6%)	6 (17.6%)	0.211[a]
Transfusion required[a]	18 (13.2%)	3 (8.8%)	4 (11.8%)	7 (20.6%)	4 (11.8%)	0.628[a]
Hepatic pedicle clamping[a]	33 (24.3%)	3 (8.8%)	11 (32.4%)	11 (32.4%)	8 (23.5%)	0.056[a]
Total hepatic pedicle clamping time (min)[b]	0 (0) (0–75)	0 (0)	0 (26)	0 (29)	0 (6)	0.052[b]
Hospital stay (days)[b]	6 (5) (2–79)	7 (3)	5 (4)	7 (5)	6 (8)	0.305b

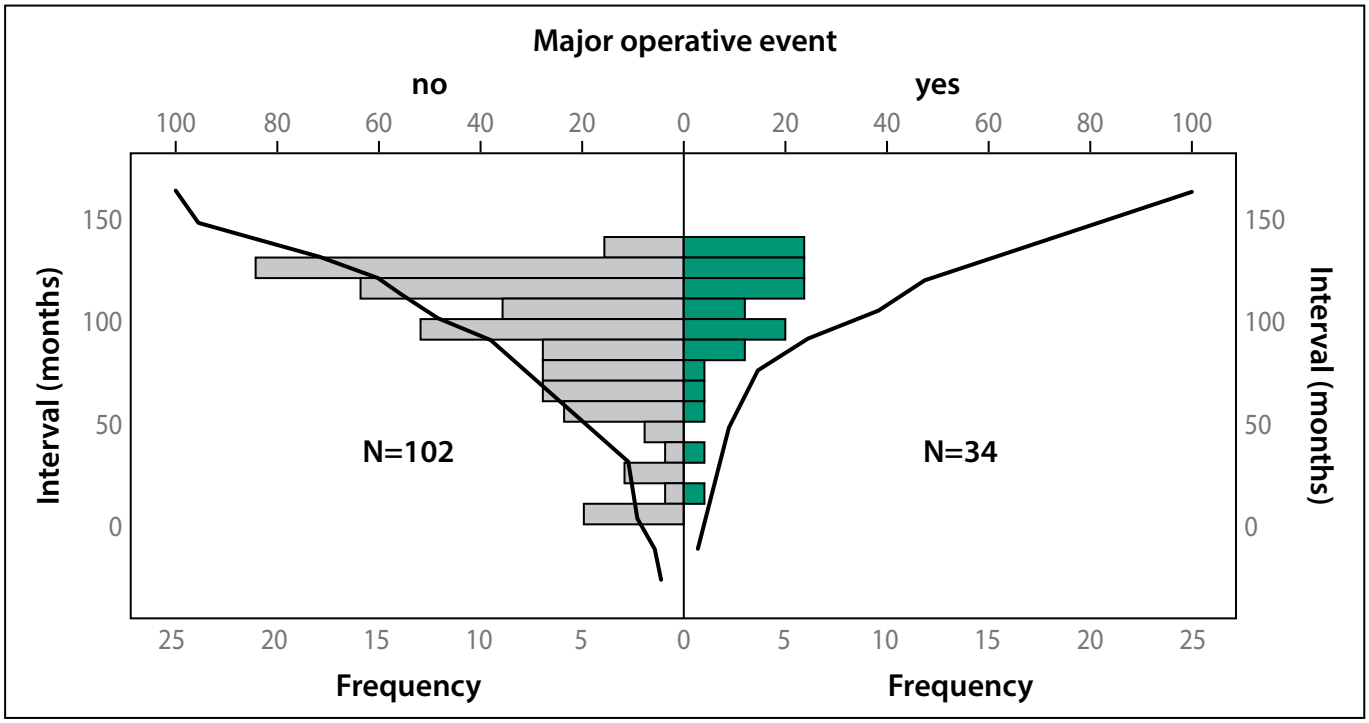
[a] = Categorical variables, Fisher–Freeman–Halton Test, [b] = Continuous variables are reported as median (IQR) (min–max); Kruskal–Wallis test; [d] =Operation time longer than 300 min, perioperative blood loss greater than 500 ml, or the presence of major postoperative complication (Clavien–Dindo ≥ 3a (29)) including mortality (15).

Table 3. Indications for conversion and postoperative complications according to the Clavien–Dindo classification.

Variables	Total *n* = 136	Group 1 *n* = 34	Group 2 *n* = 34	Group 3 *n* = 34	Group 4 *n* = 34
Indications for conversion	17 (12.5%)	1 (2.9%)	4 (11.8%)	6 (17.6%)	6 (17.6%)
Parenchymal bleeding	1 (0.7%)		1 (2.9%)		
Inability to proceed	5 (3.7%)	1 (2.9%)	3 (8.8%)	1 (2.9%)	
Oncologic concern	11 (8.1%)			5 (14.7%)	6 (17.6%)
Major morbidity CD 3a–5 (29)	18 (13.2%)	2 (5.9%)	3 (8.8%)	7 (20.6%)	6 (17.6%)
CD 3a (intervention without general anesthesia)					
Pleural effusion				1 (2.9%)	1 (2.9%)
Biloma				3 (8.8%)	1 (2.9%)
Subphrenic abscess				2 (5.9%)	1 (2.9%)
CD 3b (intervention under general anesthesia)					
Anastomotic leak after simultaneous colorectal procedure		1 (2.9%)			
Trocar site bleeding		1 (2.9%)			
Trocar site incarceration			1 (2.9%)		
Biliary peritonitis			1 (2.9%)		
CD 4a (single organ dysfunction)					1 (2.9%)
CD 4b (multiorgan dysfunction)			1 (2.9%)		1 (2.9%)
CD 5 (death)				1 (2.9%)	1 (2.9%)

CD = Clavien–Dindo classification.

Figure 2. Interval across the major operative event, Kolmogorov–Smirnov test.



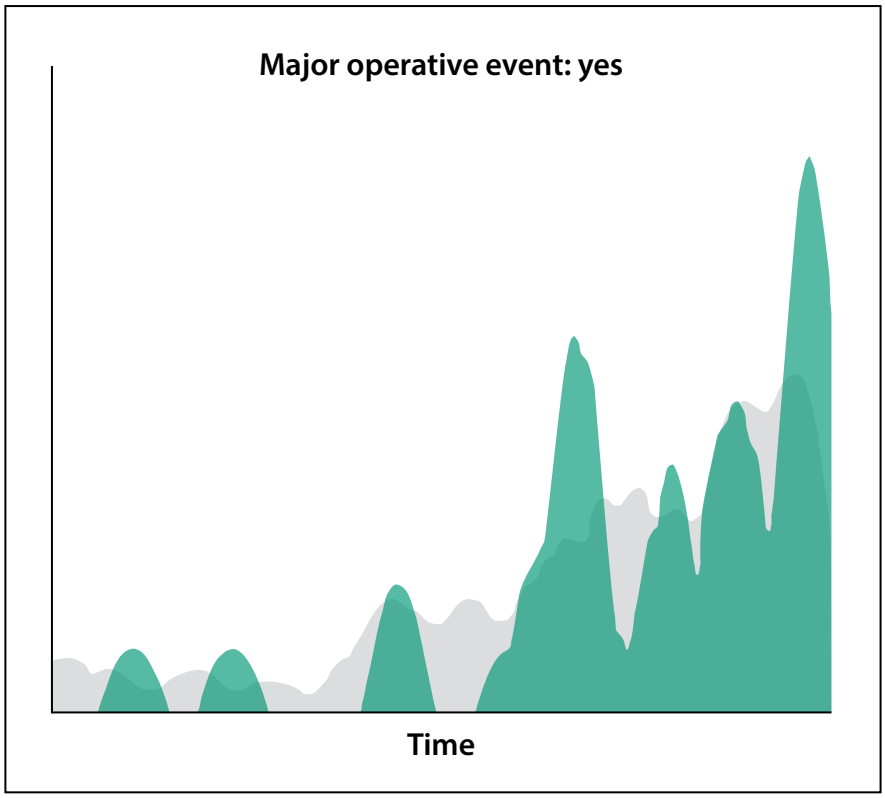


Figure 3. The Kerner smoother time-trend analysis of the major operative event. Gray = all laparoscopic liver resections; green = resections with the presence of the major operative event.

Both patients had alcoholic liver cirrhosis Child–Pugh B, were operated on for hepatocellular carcinoma, and the first died on postoperative day 10 due to sudden, unstoppable bleeding from ruptured esophageal varices. The second patient died on a postoperative day 21 after liver and multi-organ failure. However, neither transjugular intrahepatic portosystemic shunt nor salvage transplantation was indicated in these patients.

R0 resection margin was achieved in 98.5% of cases of a malignant tumor. It was not achieved in two cases in Group 2 (3.1%).

Testing the Distribution of Interval Across the Major Operative Event

Distribution analysis was used to study the association between time and MOE. The distributions are objective instruments for expressing uncertainty in data in which ranges of possible values and their likelihood are provided. The Kolmogorov–Smirnov test is a commonly used test for evaluating the difference between two distributions of continuous data (30). This test was applied with the null hypothesis that the distribution of the interval (expressed in months from the first LLR) was the same across categories of the major operative event (yes or no; Figure 2).

The test statistic values were Kolmogorov–Smirnov test = 0.990 and p-value = 0.281. The null hypothesis was retained. The Kerner smoother time-trend analysis of MOE is depicted in Figure 3.

Logistic Regression Analysis

Factors from Table 1 and Table 2 were tested one by one in binary logistic regression analysis with the MOE as a dependent variable. Statistical significance ($p < 0.05$) was reached for tumor size > 5 cm, male sex, ASA score, malignancy, posterosuperior location, deep location, major resection, technically major resection, presence of liver cirrhosis, and conversion. These factors were then used in binary logistic regression with the Enter method. The results are shown in Table 4.

The omnibus tests of model coefficients showed statistical significance of the model (< 0.001). The Nagelkerke R Square () value was 0.416. Values of the Hosmer–Lemeshow test were χ^2 = 12.441 and p = 0.087.

Table 4. Logistic regression analysis.

Variable	Coefficient	*p*-value	Odds ratio	95% confidence interval[a]	
				Lower	Upper
Tumor size > 5 cm	1.699	0.002	5.470	0.638	3.337
ASA score	0.694	0.043	2.001	0.065	1.550
Deep location	2.336	< 0.001	10.345	1.364	4.038
Liver cirrhosis	1.884	0.002	6.577	0.633	3.503
Constant	-4.499	0.000	0.011	-7.583	-2.842

[a] = Calculated by bootstrapping

At the significance level $p < 0.05$, the following variables were related to MOE: tumor size > 5 cm 5.5% (95% CI (0.6; 3.3)), ASA score 2.0% (95% CI (0.065; 1.5)), deep location 10.3% (95% CI (1.4; 4.1)), and liver cirrhosis 6.6% (95% CI (0.6; 3.5)).

For area under curve of 0.840 (95% CI (0.748; 0,931)), with a threshold of 0.5, the sensitivity was 88.2% and specificity was 61.8% (Figure 4). The *p*-value was < 0.001.

Then a new threshold was set at 0.21. For area under curve of 0.840 (95% CI (0.748; 0.931)), with a threshold of 0.21, the sensitivity was 79.4% and specificity was 73.5% (Figure 4). The *p*-value was < 0.001.

The chi-squared test compared the old and a new threshold. The result showed a statistical significance between thresholds ($\chi^2 = 29.854$; $p < 0.001$).

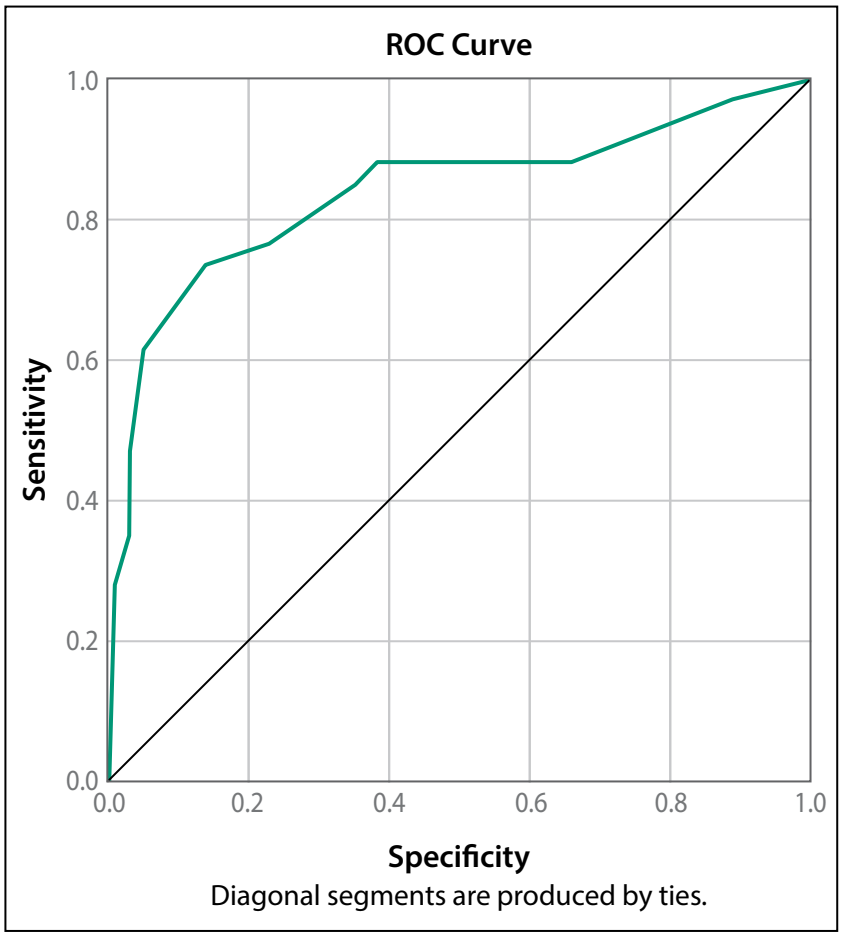


Figure 4. Receiver operating characteristic curve of the logistic regression model.

Discussion

This study was designed to investigate a single surgeon and institution learning curve of LLR. It was not a single procedure, and the complexity of operations varies from wedge resections to extended major hepatectomies. This fact contributes to difficulties during learning and assessing the learning curve (6–19).

The initial analysis showed that the annual volume of LLR has progressively increased since 2008 (Figure 1). To evaluate the effects of the experience on outcomes, we divided our study results chronologically into four periods. Thus, a comparison was made between four consecutive groups of 34 patients (6). The proportion of LLR gradually increased over four periods: 7.6%, 22.8%, 37.0%, and 39.0%, respectively. Six years to complete the first period might be considered an excessively long span, but it demonstrates the caution and strict selection criteria applied at that time. Challenges in organization, assistance, and supplies had to be overcome. The expanded range of LLR procedures was related to advances in both technology (instrumentation) and technical skill with conceptual changes. As our experience with LLR has improved over time, we have embarked on more complicated procedures. Consequently, the following periods were completed more rapidly; in 25, 16, and 14 months. These results were consistent with previous studies, in which most centers reported an increase in the proportion of LLR from 17% in early periods (6, 17) to 24% (6), 49% (17), 58% (10), or even up to 95% (13) in later periods.

Our series demonstrates the parallel development of procedures and indications, illustrating the significance of the learning process in clinical practice. The statistically significant differences between the four groups in terms of a patient (age, ASA score, and previous laparotomy) and tumor characteristics (malignancy and tumor location) reflect a strong bias in the patient selection criteria (Table 1). Although increasing size of a tumor might not be considered a limiting factor (31), the increased difficulty of resecting large lesions has already been documented (32). Similarly, in the authors' experience, larger tumors have proven to be more difficult to manipulate laparoscopically. A much longer incision is required to remove them, diminishing the benefits of a minimally invasive procedure. Thus, the proportion of LLR for lesions larger than 5 cm has not changed over time.

Our 12-year experience has reflected the stepwise evolution from anterolateral segments to tumors located in the technically challenging posterosuperior segments of the liver (Table 2) (23–24). Laparoscopic major and technically major hepatectomies were attempted after competency with less technically demanding LLRs (13, 16–17). The overall (15.4%) and increasing rates of major hepatectomies corresponded to the reported rates of 9% (6), 15% (7), and 17% (14).

Along with expanding the indications to more intricate cases that increased the difficulty of LLR, an increasing trend (11.8%, 26.5%, 29.4%, 35.3%) of MOE was observed, although it was statistically insignificant (Table 2). The distribution analysis results showed no statistically significant difference among the presence or absence of MOE according to the time interval (Figure 2).

LLR encompasses different procedures, each with its own anatomic and procedural considerations. Komatsu et al. (17) demonstrated an ideal learning curve effect for left lateral sectionectomy and left hepatectomy, but it was not observed for right hepatectomy. The observed increase in MOE resembled a cycling learning curve pattern, in which periods of improvement were followed by regression (14) (Figure 3).

Nevertheless, the median operation time, blood loss, and transfusion rates did not change significantly over the periods. Blood loss greater than 500 ml was significantly higher in Group 2. Moreover, hepatic pedicle clamping and its duration decreased in Group 4, consistent with some previous reports (6, 12).

Furthermore, our conversion rate of 12.5% did not deviate from reported rates, ranging from 1% to 17% (6–17, 33). Factors associated with an increased risk of conversion are neoadjuvant chemotherapy, previous open liver resection, malignant tumor, size, and anatomically major and technically major resection (34). The conversion rate did not change significantly throughout the study period. According to a recent report, patients that had an elective conversion for an unfavorable intraoperative finding had better outcomes than patients that had an emergency conversion secondary to an adverse intraoperative event (34). All our converted cases occurred in malignant tumors. None of the cases were related to severe, life-threatening bleeding, and the most common reasons for conversion were inability to proceed and oncological concern. The principle of

the surgery was the same regardless of the method. Ensuring an oncologically uncompromising resection was more crucial than the laparoscopic completion of the procedure. In summary, these conversion rates reflected the surgeon's confidence in dealing with adverse intraoperative findings using the open method.

Despite several difficulty scores for LLR (35–40), we performed a logistic regression analysis of factors associated with MOE (Table 4). Although the first LLR was performed in 1996 (41), the first difficulty score was not published until 2014 (42). Our first LLR was performed in 2008, and the surgeon had to rely on his experience from open liver surgery, which was also evident from the logistic regression analysis. The MOE was associated with large tumors, ASA performance status, deep location of the tumor within the liver, and liver cirrhosis (Table 4). It would be interesting to study the results of the surgeon's trainees (43–44), who could benefit from the evolution of techniques, learning modules (14, 18), and difficulty scores (35–40).

The overall major morbidity and mortality rates of 13.2% and 1.5% (Table 3) were in line with reports in the literature (14, 16, 17). A slight improvement in a decrease in major morbidity was detected, as reported (6, 12).

This study has several limitations associated with its retrospective nature. The number of patients included was relatively low. Although this emphasizes the highly selective nature of the cohort of patients with liver tumors that were considered for the laparoscopic approach in the early period of the study, the small sample size had statistical disadvantages.

To conclude, the adoption of LLR has been growing since the first consensus on laparoscopic liver surgery in 2008. Indications extended to patients with more serious conditions and malignant diseases. A shift from non-anatomical peripheral wedge resections to major liver resections over the last 12 years at this institution was documented. Our findings highlighted the importance of patient selection in the early phase of the learning curve (45) and a cautious approach to implementing a new laparoscopic liver service. The interchanging pattern of MOE indicates an ongoing "true" learning process for more vulnerable patients and complex resections. Junior surgeons could benefit from individuals' experiences in performing LLR along the learning curve and applying difficulty scores.

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Implications of Ligating an Aberrant Left Hepatic Artery During Laparoscopic Gastrectomy

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Key words

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Abstract

Background. Gastric cancer is one of the most common cancers in Europe for both men and women. Risk factors are diets rich in salt and fat and *Helicobacter pylori* infection. One type of gastric cancer is gastric adenocarcinoma, with its own subtypes. The gold standard for treating this neoplasm is either open or laparoscopic radical gastrectomy with D2 lymph node dissection. During this procedure, the surgeon must identify whether an aberrant left hepatic artery is present. If this is not done, this could lead to serious consequences such as liver abscess, liver failure, and in the worst cases death.

Case presentation. We present the case of a 74-year-old patient with a histologically verified gastric adenocarcinoma that underwent laparoscopic gastrectomy with D2 lymph node dissection with a present and preserved aberrant left hepatic artery. The operation time was 280 minutes. Liver enzymes (alanine and aspartate aminotransferase) were elevated on the 1st postoperative day and then returned to reference values within 2 weeks. There were no reported complications after the operation. We performed a retrospective study comparison of the 74-year-old patient after laparoscopic gastrectomy with D2 lymph node dissection and a ligated aberrant left hepatic artery with institutions that perform laparoscopic gastrectomies with preserved or ligated aberrant left hepatic arteries.

Conclusion. Laparoscopic gastrectomy is a safe and feasible procedure. The surgeon performing the procedure must be skilled and must identify whether an aberrant left hepatic artery is present using CT diagnostics in preoperative staging. If possible, we should preserve an aberrant left hepatic artery because severing it could lead to potential complications.

Introduction

The treatment of choice for gastric cancer is either open or minimally invasive radical gastrectomy with D2 lymph node dissection (1). In recent years, laparoscopic gastrectomy has become more popular for selected patients because it has been shown to be safe and feasible in prospective randomized controlled trials. In addition, it has many functional advantages compared to open surgery, such as faster recovery of bowel function, less pain, and a shorter hospital stay. However, laparoscopy presents a remarkable challenge when anatomical variants are encountered. When performing this procedure, the surgeon needs to identify and either safely ligate or preserve the vascular components. One of these components is an aberrant left hepatic artery (ALHA) (1–3).

The anatomical course leading up to an ALHA begins with the celiac trunk at the level of the 12th thoracic vertebrae. It gives off three branches; namely, the common hepatic artery, left gastric artery, and splenic artery. An ALHA originates from the left gastric artery and is present in about 25% of patients either as a replaced left hepatic artery (a substitute for the normal left hepatic artery, which occurs most often) or as an accessory left hepatic artery, which is an additional blood vessel. It supplies the left lobe of the liver; specifically, segments 2 and 3. It runs within the hepatogastric ligament just anteriorly to the caudate lobe and into the left lateral liver lobe. During embryonic development, the primitive liver has three embryonic hepatic arteries—namely, the common, left, and right hepatic arteries. The left and right hepatic arteries normally undergo a process of regression. If they persist, they then develop into an ALHA (4–7).

The first to describe such anatomical variation was Von Haller in 1764, who termed them *arteriae hepaticace accesoriae*. Then, in 1873, Hyrtl reported an occasional hepatic artery with branches that make this artery superfluous. Finally, Michel made the first classification of hepatic arterial variations, 10 altogether: type I: normal pattern type; type II: replaced left hepatic artery from the left gastric artery; type III: replaced right hepatic artery from the superior mesenteric artery; type IV: replaced right and left hepatic artery; type V: accessory left hepatic artery; type VI: accessory right hepatic artery; type VII: accessory right and left hepatic artery; type VIII: replaced right or left hepatic artery with another hepatic artery being an accessory artery; type IX: the hepatic trunk as a branch of the superior mesenteric artery; and type X: the common hepatic artery from the left gastric artery. Later on, Hiatt and Varotti modified this system. Hiatt joined the accessory and replaced left hepatic artery in the same group (Michael's type II), and Varotti introduced two subtypes: type 2a for the accessory left hepatic artery and type 2b for the replaced left hepatic artery (8).

During gastrectomy it is important to recognize an ALHA because any injury or ligation can lead to liver injury in patients with a preexisting liver injury. The first pathological change that can be seen is elevated liver enzymes (aspartate and alanine aminotransferase), but these usually return to normal values within 2 weeks. Then comes the formation of a liver abscess, for which the treatment of choice is antibiotic treatment with percutaneous US- or CT-guided drainage, or open or laparoscopic drainage and lavage. In extreme cases, the patient can quickly develop sepsis and die. The problem arises from the fact that an ALHA feeds a wide area in the liver, the left lobe, and can therefore cause severe ischemia. Despite collateral blood flow from the common hepatic artery, these collaterals can in some cases be insufficient to supply the left lobe, and it is therefore heavily dependent on the ALHA. This means that when this circulatory path is closed liver damage occurs (5, 7, 9–11).

This article presents the case of a 74-year-old patient that underwent laparoscopic gastrectomy with D2 lymphadenectomy, with a present and preserved ALHA. We also present a brief review of literature on the incidence of ALHA and the potential dangers of its ligation.

Case Presentation

Our patient was a 74-year-old male with dyspepsia and chronic atrial fibrillation. His family history was negative regarding oncological illness. He took daily anticoagulation therapy, with no prior abdominal surgeries. He underwent gastroscopy, and an ulcer was discovered in the anterior wall of the stomach. The ulcer measured approximately 2 cm, and a histological sample was taken. It revealed that the patient had an invasive type of adenocarcinoma (Lauren classification) cT1–2 N0 M0, and a laparoscopic gastrectomy with D2 lymphadenectomy was indicated. Before the operation, the case was dis-

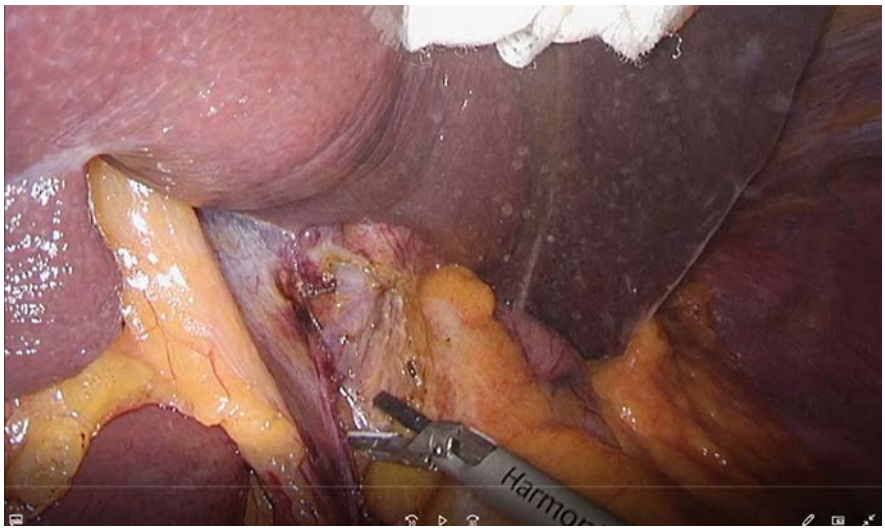


Figure 1. Dissection of the diaphragmatic crus.

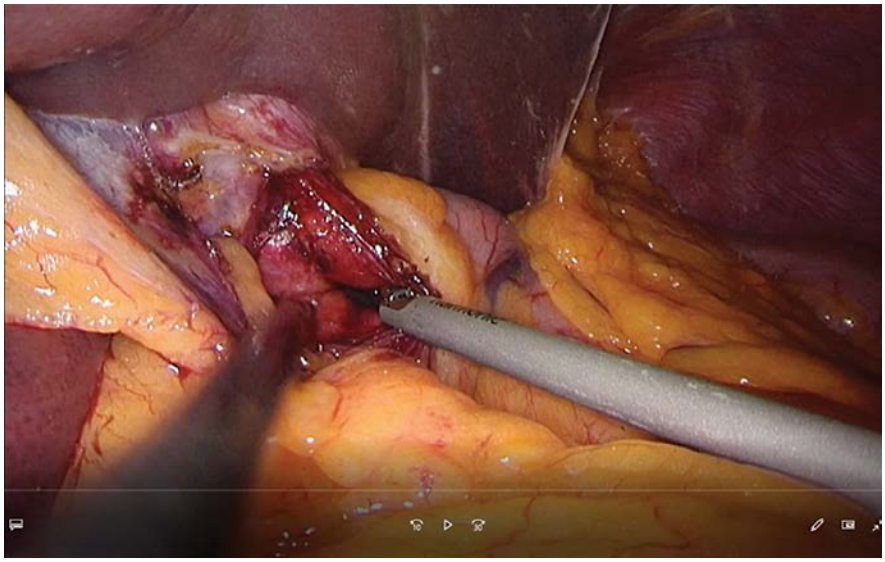


Figure 2. Blunt dissection of the retrogastric space.

cussed at a tumor board. Because of the early-stage gastric cancer, the patient was denied preoperative chemotherapy.

The procedure started with the patient secured in a decubitus prone position with arms and legs abducted. The surgeon was on the right side of the patient, the first assistant was on the left side of the patient, and the camera operator was between the legs. A 30° scope was used during the entire procedure. A standard five trocar placement was used.

The first steps of the operation were critical to obtain maximum exposure of the entire circumference of the ALHA. The complete visualization of the artery prevented unwanted injuries to the vessel. In addition, traction could be exerted over ancillary structures and not directly over the artery. This in turn prevented thrombosis of the ALHA.

The first step was dissection of the hepatogastric ligament. During this step, a wide margin of the hepatogastric ligament was left intact along Arantius's ligament in order not to injure the ALHA and to have a secure edge of tissue for left liver lobe fixation (Figure 1). During this step, the branching of the ALHA toward the third liver segment was appreciated in order to expose the right crus of the diaphragm above the arc of the artery. During this step, the esophagophrenic ligament was dissected to free the space posterior to the esophagogastric junction (Figure 1B). This space was then bluntly dissected to expose the upper part of the right crus and to free the space cranially to the celiac trunk (Figure 2).

After these steps were completed, we could proceed with the laparoscopic subtotal gastrectomy, as described elsewhere. The dissection followed

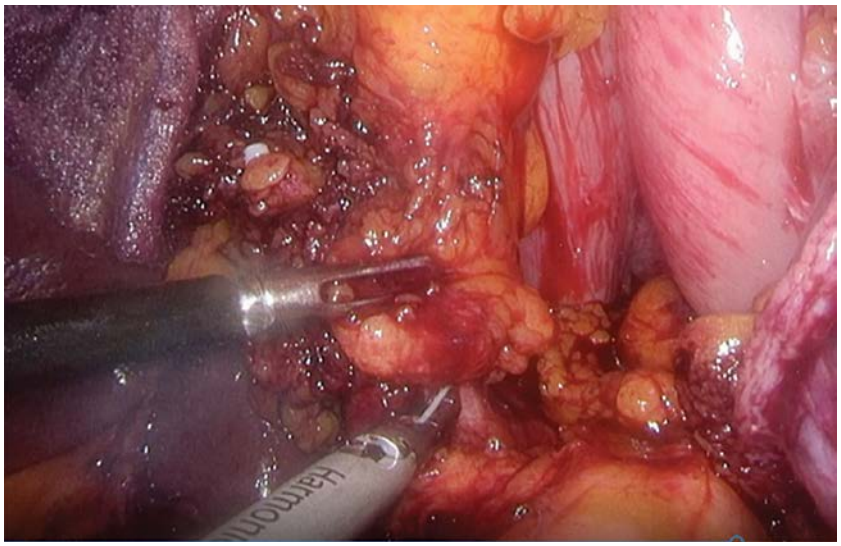


Figure 3. Dissection of the base of the left gastric artery.

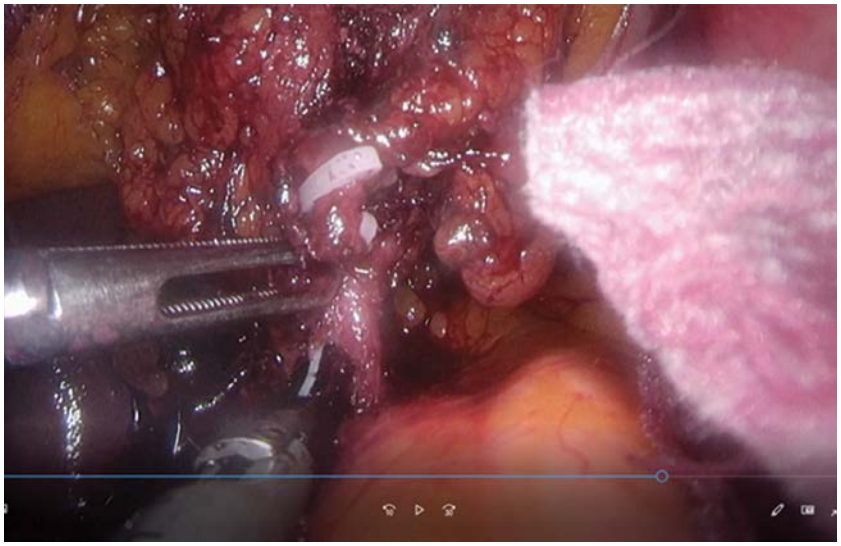


Figure 4. The base of the left gastric artery has been completely visualized.

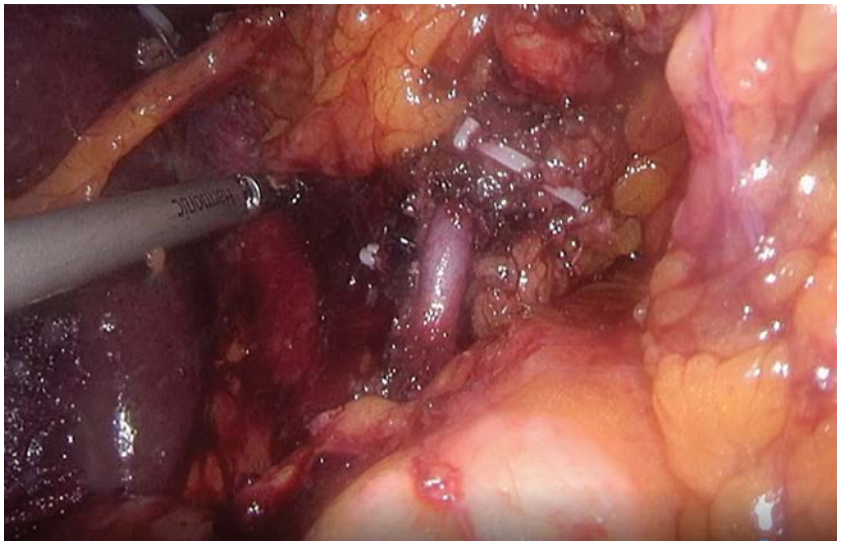
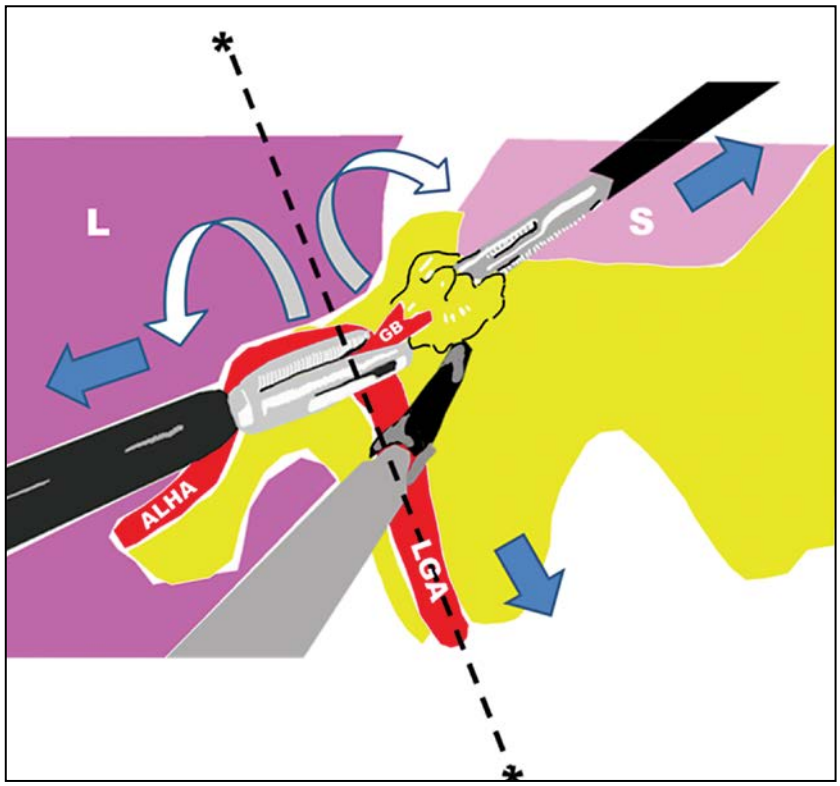


Figure 5. Dissection of the lower part of the right diaphragmatic crus.

Figure 6. The triangle principle.

Figure 7. Schematic presentation of the triangle principle. L = liver, S = stomach, LGA = left gastric artery, ALHA = aberrant left hepatic artery, GB = gastric branches. The blue arrows represent the direction of the traction. The asterisks (*) represent the axis of the dissection that continues from the base of the LGA toward the base of the ALHA. The white arrows represent the direction of the dissection around the axis of dissection.



standardized steps until the dissection of the hepatogastric ligament was concluded. Then we continued with the medial approach to the base of the left gastric artery. Again, this was a critical step before embarking on the dissection of the ALHA. Once the base of the left gastric artery was dissected (Figures 3 and 4), we could proceed with the dissection of the lower part of the right crus of the diaphragm (Figure 5).

During this step, correct placement of the grasper was critical. We followed the triangle principle, in which the assistant holds the dissected tissue with two graspers and exerts contralateral traction while the surgeon holds the tissue with his left hand and dissects the tissue with his right hand (Figure 6). The axis of the dissection was around the imaginary line of the ALHA, and the lymphatic tissue was dissected in the open book manner from the artery (Figure 7).

After we freed up the base of the left gastric artery and the right crus of the diaphragm, we started with the dissection of the upper part of the ALHA

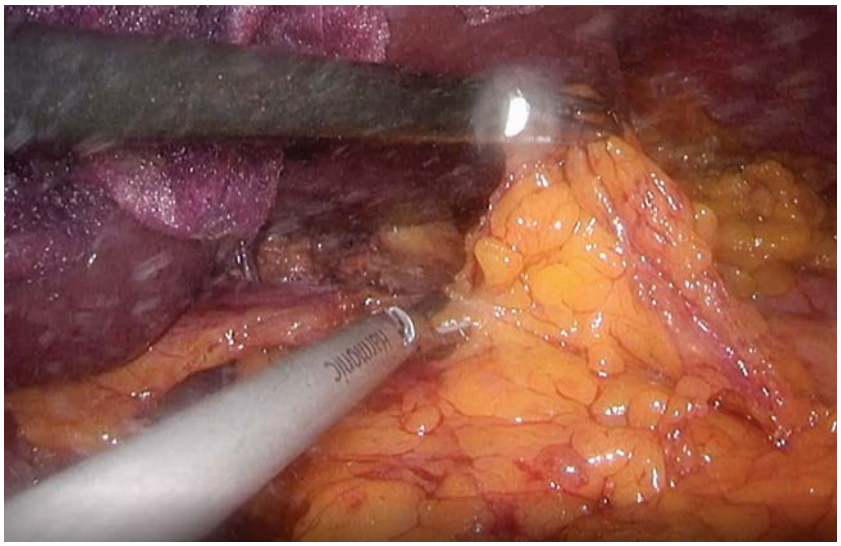


Figure 8. Dissection of the upper part of the aberrant left hepatic artery.

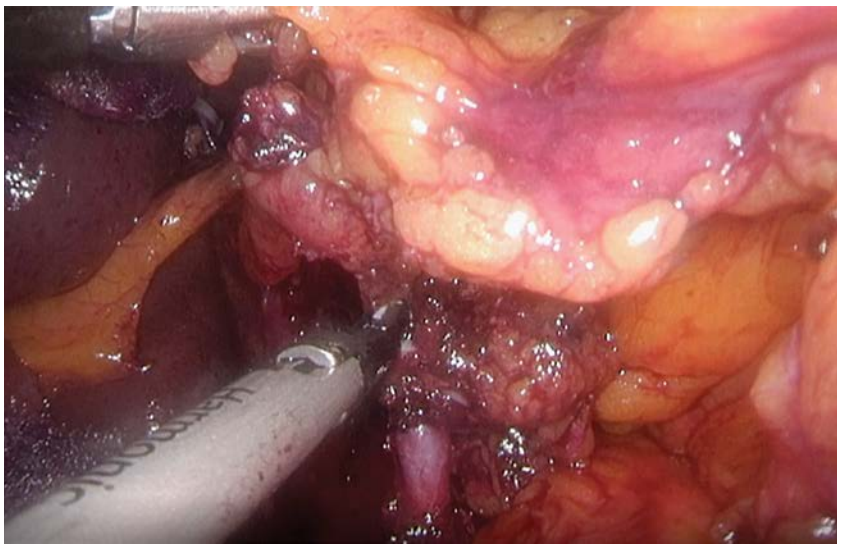


Figure 9. Visualization of gastric branches after dissection.

Figure 10. The gastric branches are visualized.

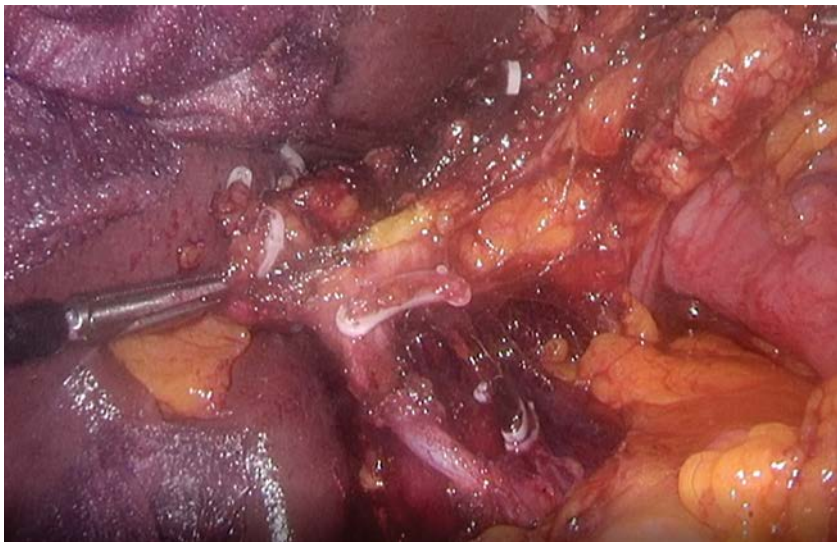


Figure 11. The aberrant left hepatic artery and the left gastric artery are completely dissected away from the stomach.

(Figure 8). The dissection of the upper part of the ALHA allowed complete visualization of the ALHA and produced the main landmarks for further dissection. Tissue was incised away from the left gastric artery below and the ALHA from above and bluntly pushed away from the dissection axis until branches to the stomach were visualized (Figure 9). The individual gastric branches were clipped and dissected (Figure 10). After the ALHA was dissected free from the gastric branches, the surgeon used a fine grasper for the ALHA and dissected the artery away from the lymphatic tissue (Figure 11). The lymphatic tissue was removed *en bloc* with the specimen.

The postoperative course was uneventful. The nasogastric tube was removed on the 1st postoperative day. Oral feeding with a liquid diet was started on the 1st postoperative day. The patient was allowed sips of clear fluid on day 1, and on day 2 he was allowed enteral feeding formula. We started with mobilization on the 1st postoperative day with sitting and continued with walking on the ward on day 3. The abdominal drains were removed on the 5th postoperative day, and the patient was discharged on day 7.

The histological analysis confirmed an invasive adenocarcinoma of the antrum. The final pathological stage was pT3 N3a M0 (Lauren classification) with an R0 resection. Among the 45 lymph nodes removed, we found eight nodes with a metastatic deposit of invasive adenocarcinoma on the lesser curvature of the stomach.

Discussion

An ALHA occurs in about 25% of patients, with the worldwide incidence being 13.52%. Similar numbers of occurrence were reported by Tiwari (2014), Okano (1993), Lurie (1987), and Maki (2018) (4, 7, 10, 11). When deciding what type of ALHA we are dealing with, visual inspection of the vessel should serve as an orientation. A replaced left hepatic artery is usually thick, whereas an accessory left hepatic artery is usually thin. When the decision during laparoscopy is unclear, the surgeon should additionally rely on either a three-dimensional contrast-enhanced CT or CT angiography. Ronson (2020), Maki (2018), and our department used such an approach in the preoperative stage (4, 5, 7, 10, 11).

The literature is united regarding the incidence of ALHAs; however, opinions differ strongly with regard to decisions on the preservation of this artery. Reports on ALHA injury range from mere elevation of liver enzymes to fatal complications. Lurie et al. described a case of ALHA transection in 1962 (10). The patient died on the 3rd postoperative day due to left liver necrosis. Since then, he has performed left lateral lobectomy six more times in cases of ALHA transection, all being successful (6, 10, 11).

Although Lurie reported fatal complications following ALHA transection, we believe that these complications can occur only in patients with preexisting liver dysfunction. When ALHA is present there are usually enough intrahepatic anastomoses that prevent ischemia. This is only

seen in patients with preexisting liver damage. Most frequently an elevation of liver enzymes follows the ligation of ALHA. Okano et al. (1993) noticed elevated liver enzymes on the first postoperative day in patients in whom he severed the ALHA in contrast to patients in whom the ALHA was left intact (11). Similarly, Ronson et al. noticed elevated alanine and aspartate aminotransferase values on the 2nd postoperative day in the RLHA ligated group. In the accessory left hepatic artery ligated group, there was an elevation of alanine aminotransferase. The values in the RLHA and accessory left hepatic artery group—both ligated and preserved—showed normalization of liver enzymes 2 weeks after operation (11). Shinohara et al. (2007) also showed similar results, with alanine and aspartate aminotransferase being elevated on the 1st postoperative day in the ALHA ligated group of patients. Liver enzymes in ALHA ligated and preserved groups returned to normal after 10 days, which is in the vicinity of other studies (6).

We believe that the high incidence of fatal liver complications described by Lurie was caused by the transection of a totally replaced left hepatic artery. In contrast to an ALHA, in which the left liver lobes are supplied with tributaries from the left hepatic artery, a replaced left hepatic artery provides the sole arterial flow to the left lateral or even left paramedian lobes. The transection of a replaced left hepatic artery can hence have more dramatic consequences. In a study performed by Ronson (2020) (11), ALHAs were divided into replaced left hepatic arteries and accessory left hepatic arteries. The ligated replaced left hepatic artery had three reported complications, and the ligated accessory left hepatic artery showed eight complications (5, 6). These cases emphasize the importance of preservation of an ALHA especially in the case of a replaced left hepatic artery, although complications can also occur in cases with an injured accessory left hepatic artery. Still, the distinction between a replaced left hepatic artery and accessory left hepatic artery before or during the operation could prevent major complications.

The presence of an ALHA can prolong an operation. Huang (2013) presented a comparison in performing laparoscopic radical gastrectomy in patients with ALHAs, in which they ligated this artery, and patients without ALHAs (12). The operation time in the first group was prolonged (204 min) in contrast to patients without ALHAs (183 min). Similarly, Maki, Shinohara, and Ronson all also showed a prolonged operation time in patients with ALHAs compared to patients without ALHAs (5–7, 12). In the case of laparoscopic subtotal gastrectomy with D2 lymphadenectomy presented, we found that the operative time of 280 min only insignificantly prolonged the operation compared to the usual duration of laparoscopic subtotal gastrectomy at our center.

Despite somewhat longer operation times, the careful dissection of lymph nodes around an ALHA is necessary. Important lymphatic structures are located around ALHAs that should be removed as part of the D2 lymph node dissection. The lymph nodes around ALHAs coalesce with the no. 7 lymph node station and present an important lymphatic basin. The incidence of lymph node metastases in these lymph nodes is high; therefore, it is necessary to remove them completely during a D2 lymph node dissection. The dissection of these lymph nodes along with the importance of preservation of a totally replaced ALHA presents a great challenge for the surgeon. This is especially true in laparoscopic surgery.

To achieve complete and safe dissection, three main principles should be adhered to. The first principle was described by Kinoshita (2017) (13). It is called the triangle principle and it not only allows the visualization of the correct plane of the dissection, but also produces the necessary tissue tension for the dissection. It is important that the first assistant use traction with two atraumatic graspers forming the base of the triangle, while the surgeon forms the apex of the triangle with one grasper. The next principle is the preparation of the tissue and visualization of key landmarks. The surgeon should always visualize the upper part of the ALHA as it enters Arantius's ligament. Second, he should always perform the complete dissection of the base of the left gastric artery. These two landmarks serve as markings for the further dissection. The third and final principle is dissection in the open book fashion with the axis of the dissection along the ALHA. The assistant should continuously exert traction toward the left, while the surgeon exerts traction to the right. The dissection continues over the free edge of the vessel to finally expose the free gastric branches that stem from the free edge of the left gastric artery. Clipping and cutting of the left gastric artery is the final step, leaving the lymphatic tissue *en bloc* with the specimen. These three steps allow a safe dissection. The extent of the operation is prolonged by an additional half hour (13).

In conclusion, we are left wondering whether a surgeon should preserve an ALHA or not. In the majority of cases, ligation of an ALHA produces only a transient elevation of liver enzymes; however, due to numerous reports and our own experience, we believe that in each case the surgeon should determine whether an ALHA is a replaced left hepatic artery or an accessory left hepatic artery. This should be done with preoperative diagnostic imaging modalities and with intraoperative visual inspection. Arteries with a larger diameter are more likely to be totally replaced, and potentially lethal complications could result in inadvertent ligation. Therefore, surgeons should preserve a replaced left hepatic artery. In the case presented, we have showed that preservation of a replaced left hepatic artery can be safely performed during laparoscopic gastrectomy. The operation times are only negligibly prolonged with no serious complications. Because important lymph node basins follow the course of an ALHA, lymph node dissection of this region is mandatory. We have shown that, by adhering to the triangle principle, laparoscopic lymphadenectomy of this region is feasible and safe. Because the incidence of this anatomical variation is low and the surgical steps are demanding, we recommend that in the case of a replaced ALHA an experienced laparoscopic surgical team should perform the surgery.

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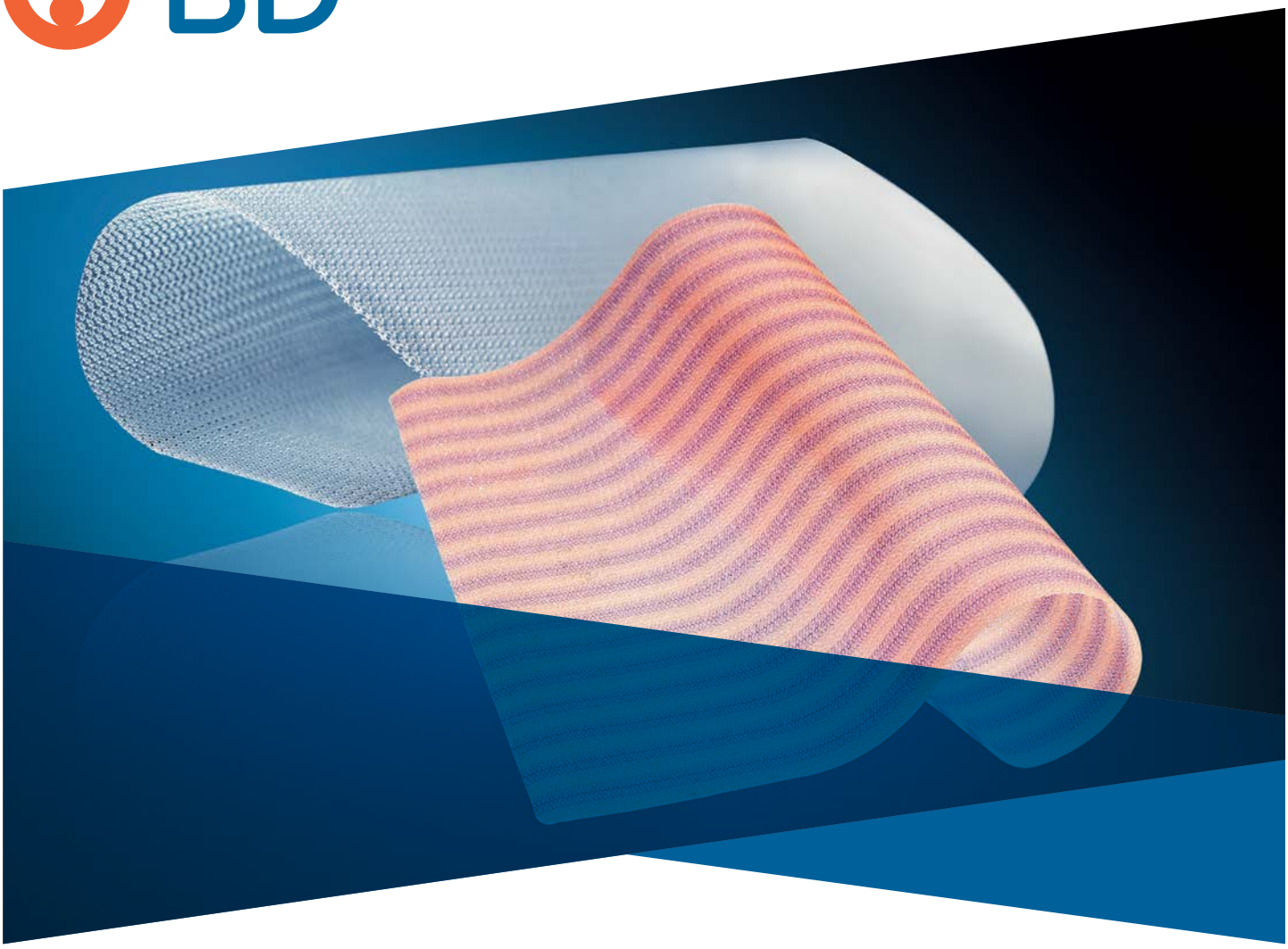

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The Resident Learning Curve in Transabdominal Preperitoneal Patch Plasty at Izola General Hospital: Are We Prepared for a Standardized Curriculum?

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Key words

standardized curriculum, step-by-step learning, TAPP

Research Article

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Abstract

Background. No standardized curriculum exists for general surgery residents for learning laparoscopic hernia repair in Slovenia. Endoscopic techniques have proved to be a cost-effective treatment for inguinal hernia with a low incidence of postoperative pain and fast recovery. After implementation of transabdominal preperitoneal patch plasty (TAPP) at general hospitals across Slovenia, the question remains if we are prepared and ready for resident learning of this novel but technically demanding procedure.

Methods. A literature review focused on how endoscopic techniques are implemented in learning practice. An analysis was performed of the mean number of procedures per capita for four specialists that perform TAPP daily and two residents involved in learning this operation in 2019 at Izola General Hospital.

Results. Numerous publications and studies point to the absence of appropriate learning of laparoscopic hernia repair by trainees and at the same time prove that it is a safe method for treating inguinal hernia in the hands of a surgical resident while under the supervision of an experienced laparoscopic surgeon that deals with relevant cases daily and is working and teaching at an institution with a sufficient case load and standardized technique.

Conclusion. We need to refresh our teaching goals and standardize a step-by-step learning approach for learning TAPP.

Introduction

Inguinal hernioplasty is one of the first procedures performed by a trainee in the learning curve during surgical residency. Traditionally, the open approach was the goal of teaching. Today, it is insufficient due to the wide spectrum of surgical treatments offered to patients, and the desired laparoscopic technique should be mastered to satisfy all goals and principles of modern herniology. A lower incidence of postoperative pain and faster recovery are the main benefits recognized compared to open repair (1). It is also a cost-effective approach and is associated with higher quality of life at lower costs (2). Transabdominal preperitoneal patch plasty (TAPP) was widely introduced at Slovenian general hospitals between 2013 and 2018 after completion of the laparoscopic workshop with the invited guest Reinhard Bittner at the Ljubljana Medical Center (3).

This article investigates data from the literature regarding resident learning of laparoscopic inguinal hernia repair and specifically compares these data to Izola General Hospital. The question remains whether we are experienced enough and prepared to propose a standardized curriculum for learning the TAPP procedure for residents in the future.

Methods

A literature review focused on how endoscopic techniques are implemented in learning practice. An analysis was also performed of the mean number of procedures per capita for four specialists that perform TAPP daily and two residents involved in learning this operation in 2019 at Izola General Hospital.

At Izola General Hospital, the first TAPP was performed in 1994, but the technique was reserved for selected patients only. However, from 1994 to 2002, 201 hernias were treated laparoscopically. From 2014 to 2018, 318 patients were operated on using the TAPP technique (4). In 2018, TAPP and the Lichtenstein procedure were performed for the management of inguinal hernia in Slovenia in 14% and 86% of cases, respectively (3). Fresh data from 2019 at Izola General Hospital show an increase in the percentage of TAPP to 57%, or 256 out of 453 cases.

The key point to achieve resident learning is education and learning at a center where laparoscopic inguinal hernia repair is well standardized and completely integrated into daily routine work (2).

Results

The performance of a laparoscopic inguinal hernia repair requires unique technical and cognitive skills that, until recently, were not routinely taught to general surgeons (5). The guidelines of the European Hernia Society recognize the learning curve for TAPP as distinct due to greater complexity. Training components are both cognitive and technical: groin area anatomy, procedural steps, intraoperative decision making, and manual dexterity (6).

In a systematic review by Kockerling in 2018, the learning curve for TAPP was reported to be around 50 to 100 procedures (7). The learning curve for totally extraperitoneal (TEP) repair shows some variation; however, it appears that, on average, more than 100 repairs are required to achieve outcomes comparable with open anterior mesh repair (6). In comparison, follow-up of 69 trainees from the United Kingdom in 2016 showed that the mean number of operations needed for open inguinal hernia at an independent level was 64 and is attained in the 4th year of training (8).

In Slovenia there are no approved mandatory endoscopic courses within the curriculum for general surgery. The expected case load is limited to 30 hernia repairs within 6 years of training, with no specification regarding the types of hernia or the manner (open or endoscopic) in which it should be mastered (9). Data presented in 2019 at the 14th Slovenian Congress of Endoscopic Surgery in Portorož once again proved the absence of a standardized curriculum for laparoscopy training during residency as well as all endoscopic procedures (10).

Many studies indicate that surgical trainees are not receiving sufficient experience and are failing to reach nationally identified targets (11). It is also clear that mentoring and strict supervision by an experienced endoscopic surgeon is crucial in the educational process. This almost eliminates potential negative implications for the patient, such as technical errors and recurrence (7).

Nonetheless, one study associated open and laparoscopic hernia repairs performed by junior residents with higher recurrence rates than those repaired by senior residents, despite the presence of an attending surgeon (12). However, with an expanding case load, the longer operative time can be neglected, and in the long term it does not have an effect on the patient's welfare. The trainees also demonstrated continuous improvement in terms of the operation time (1). Accordingly, the specialists supervising trainees when performing surgical procedures should themselves conduct a minimum number of the most important hernia surgery procedures each year (7). This is now specified at specialized hernia centers with objectively proven expertise.

Annual caseload specifications for individual hospitals and each surgeon have important implications for patient outcome (13). A Herniamed registry–based analysis of 16,240 laparo-endoscopic (TEP, TAPP) primary inguinal hernia repairs in 2018 showed that low-volume surgeons (< 25 procedures per year) have significantly higher recurrence and pain on exertion rates than high-volume surgeons (25 procedures per year) (13).

At Izola General Hospital, 256 patients underwent laparoscopic inguinal hernia repair in 2019. Divided between four specialists, the highest case load was 96, 72, 46, and 40 operations, respectively. The mean number per specialist was 64 repairs. At the time of writing this article, two surgical residents are in the last 2 years of their general surgery residency. They have not performed the entire procedure on their own, but they have performed parts of the operation. The mean number of procedures with active participation is 10, and it includes peritoneum suturing and dissection of the preperitoneal space.

Discussion

Studies have indicated that surgical trainees are not receiving sufficient experience. Reasons for this include the technical difficulty of laparoscopic surgery as well as the lack of structured training programs (7).

In 2008, the Italian School of Hernia and Abdominal Wall Surgery was created, the first in Europe, as an educational branch of the Italian Society of Hernia and Abdominal Wall Surgery (ISHAWS). In 2009 it was officially presented to the international community (14). In 2011, the concept of a hernia school was developed in Germany and has been gradually implemented ever since. These simulation-based training courses could also be part of a standardized curriculum concept for continuing training in hernia surgery (15).

Zendejas et al. were the first to demonstrate that simulation-based mastery learning decreased operating time, improved trainee performance, and decreased intra- and postoperative complications after laparoscopic inguinal hernia repair. Skills training consisted of supervised practice sessions using the Guildford MATTU TEP hernia model and standard laparoscopic equipment (16). A similar model was developed in cooperation with the company Karl Storz and is called the Bittner Training Hernia Module (1). It allows simulation of four steps of TAPP: opening the peritoneum, placing a 10 × 15 cm mesh, fixating it, and closing the peritoneum through suturing (17, 18).

In a prospective randomized trial, it was found that for inguinal hernia surgery with the TEP technique a simulation-based mastery learning course led to a reduction in the operative time, improved trainee performance, a reduced intra- and postoperative complication rate, and a lower hospital admission rate (16). Laparoscopic box model training appears to improve technical skills compared with no training in trainees with no previous laparoscopic experience (19). Bockeler et al. reported on complete and strict standardization of TAPP for learning reasons. The requirement for young trainees to be included in the learning curve was to guide the camera at least 50 times (1). Second, they were required to already have some experience with laparoscopic operations (25 laparoscopic cholecystectomies) (1). Third, all operations were performed under the guidance of experienced surgeons; thus, many pitfalls and intraoperative problems could be anticipated, and possible complications prevented (1).

From the data presented above, it can be concluded that in Slovenia there is no standardized curriculum for endoscopic learning for general surgery residency. Performing core laparoscopic procedures, such as appendectomy and cholecystectomy, with guidance or independently is a strong fundamental before moving forward to active involvement in the TAPP procedure. The next step is performing part of the procedure, preparation,

or peritoneal flap suturing. It is best to start with intraabdominal suture closure of the peritoneum because there is no danger to the patient (1). This is followed by opening of the peritoneum and preperitoneal space dissection with mesh placement. In almost all cases, surgeons at Izola General Hospital use a self-gripping mesh, and very rarely fixation with glue is used. Dissecting the hernia sac is technically the most difficult and dangerous (1). The last step would be performing the entire procedure under supervision.

Conclusion

TAPP is a safe procedure in the hands of a surgical resident that has gained prior expertise in core laparoscopic procedures, but it must be meticulously supervised during the learning curve. There is also a need to refresh the general surgery curriculum in the light of the exponential rise of numerous endoscopic techniques. This would offer an opportunity for residents and young surgeons to stay in touch with the latest trends in treating hernias.

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Intestinal Obstruction Due to Ileocolonic Intussusception: Two Case Reports with a Literature Review

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Key words

ileocolic intussusception, bowel obstruction, giant colonic lipoma, colon cancer

Case Report

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Abstract

Intestinal intussusception is a condition in which a proximal portion of the intestine folds into a more distant part, obstructing its lumen. Its presentation is usually with acute patient distress due to bowel obstruction or ischemia. In adult patients it is usually associated with a lead point, which is most commonly a malignant tumor. We present two case reports of female patients that suffered from ileocolic intussusception. In the first case, the intussusception was caused by a colonic lipoma, which led to partial bowel obstruction and transient intussusception. In the second case, the intussusception was caused by a large malignant tumor of the colon.

Introduction

Intussusception is a medical condition in which the proximal portion of the intestine folds into the more distant part, forming a structure reminiscent of a telescope (1). The part that invaginates is called the *intussusceptum* and the receiving part the *intussuscipiens* (2). Depending on the part of the intestine that is involved, different names can be used for the intussusception, and they reflect the anatomical location of the pathology; for example, enteroenteric, ileocolic, colocolic, rectoanal, or stomal (3, 4). Intussusception represents approximately 1 to 5% of adult intestinal obstructions (5). It is more frequent in children, where it is usually idiopathic, whereas adult intussusception is usually due to an intestinal mass, which serves as a lead point (4, 6). It acts as a traction point that draws the proximal segment of the intestine into the distal segment. Peristaltic contractions then continue against the obstruction, eventually leading to the symptoms. Left untreated, intussusception leads to edema of the affected intestine, compromised blood flow, and finally to necrosis and perforation of the affected segment (3, 7).

When intussusception affects the small intestine, it is more likely to be due to a benign lesion. When a malignant tumor was found as a reason for enteric intussusception, it was mainly connected with metastatic disease (carcinomatosis); however, several studies and case reports have also emphasized the possibility of metastatic melanomas as a possible lead point (3, 8, 9). When intussusception develops in the colon (whether ileocolic or colonic), it is most likely connected with a primary adenocarcinoma. This is the case in 61.7% of ileocolic and 78.8% of colonic intussusceptions (9–12). The most common benign lesion associated with colonic intussusception is colonic lipoma. Adenoma and inflammatory pseudopolyps were described as other possible causes (3, 9–12).

The symptoms are usually nonspecific and include abdominal pain, nausea, and vomiting (1, 2). Because of the diverse clinical presentation, the diagnosis can be difficult, especially in subacute and chronic clinical presentations (13).

There are multiple possibilities for diagnostic imaging tests that can be used to identify intestinal intussusception. These include barium enema, colonoscopy, X-ray, US, CT, and MRI (2, 5, 6). Colonoscopy is used only in selected cases when lesions that might be identified and biopsied are presumed to be present in the colon (2). The most useful imaging modality is a contrast-enhanced CT scan of the abdomen because it offers a precise picture and it provides information about length, diameter, the part of the intestine involved, the possibility of strangulation, and a possible lead point (14).

The usual manner of resolving intussusception in an adult is with an operation (13, 14). Non-operative management includes hydrostatic reduction, which is an elegant way of resolving intussusception mostly in the pediatric population, usually in combination with US (5, 13, 14). The most common operative treatment is resection of the affected intestine (13). The decision on a preoperative attempt at reduction of the intussusception remains somewhat controversial. Preoperative manipulation presents a risk of intraluminal seeding, venous dissemination of malignant cells, possible perforation of the intestine, and increased risk of anastomotic complications (which originate in the edematous and inflamed intestine) (3, 7, 15). Some case reports and single-center studies showed that preoperative manipulation is possible and safe for a selected group of patients (1, 7, 16). It seems that most of the studies are in favor of en bloc surgical resection regarding the oncological principles, without a preliminary attempt at reduction (7, 12). Depending on the patient's clinical condition, preoperative radiological findings, local expertise, and medical history laparoscopy can be used as a surgical approach, whereas laparotomy remains the standard approach (3, 7, 17).

Case Reports

Patient 1

A 41-year-old female patient with no significant medical history sought medical attention at our hospital due to nausea, 10 kg weight loss in 5 weeks, and occasional pain in the lower abdomen. Gastroscopy was performed and showed a bulge on the body of the stomach with the normal gastric mucosa. Colonoscopy revealed a suspicious tumor-like excrescence in the part of the ileocecal valve. No obstruction was seen on the colonoscopy, and the terminal ileum was reached. The analyzed biopsy samples proved it to be a submucosal lipoma. Only contrast-enhanced CT of the abdomen revealed a huge intussusception (Figure 1), extending to the hepatic flexure of the colon, caused by a colonic lipoma that measured 5.5 × 3.8 cm. The patient was admitted for surgical treatment and underwent a laparoscopic right hemicolectomy. Histological examination revealed a lipoma of the ascending colon. The postoperative course was uneventful and on the 6th day after the operation the patient was discharged. At the follow-up examination she was in good condition with no residual symptoms.

Patient 2

The second patient is an 84-year-old female that came to our emergency department because of abdominal pain and constipation that lasted around 3 weeks. During this period, she lost 7 kg and was defecating only liquid stool. Her past medical history was significant for hypothyroidism, and she had no prior history of abdominal operations. During the clinical examination a diffusely tender abdomen was found. Abdominal X-ray showed signs of small intestine obstruction. CT scan described a huge intussusception that encompassed

Figure 1. Coronal view of the CT scan in which the colonic lipoma can be seen at the hepatic flexure, causing ileocolonic intussusception.

the terminal ileum, cecum, and ascending colon, which were all intussuscepted into the transverse colon with no visible lead point. The intestine was viable, without signs of ischemia or perforation. Obstruction of the small intestine proximally to the intussusception was also described. Laboratory findings showed raised CRP (53 mg/l) with a normal level of leukocytes.

She underwent an urgently operation on the day of admission. We decided on open surgery because of signs of small bowel obstruction. Reduction of the intussusception was unsuccessfully attempted. Given the age of the patient, irreducibility, and location of the intussusception, there was a strong suspicion of a malignant tumor serving as a lead point, which is why further attempts at manual reduction of the intussusception were abandoned. We proceeded with an extended right hemicolectomy and primary anastomosis. The postoperative stay at our clinical department was uneventful, and the patient was discharged on the 11th postoperative day. Histological findings confirmed adenocarcinoma of the caecum (T3 N1a), and the surgical margins were free of cancerous growth. The tumor was 9 × 4.5 cm and was macroscopically described as polypoid. The patient did not receive adjuvant treatment, and she is still disease free after 1 year.

Discussion

Intussusception is rare in adults, but certain diseases may contribute to its development (4, 6). The cause for it in Patient 1 was a submucosal lipoma, which is the most common benign cause of intussusception in adults (18). In our case, the lipoma was 5.5 cm in length; it has been shown that gastrointestinal lipomas larger than 4 cm are associated with a higher risk of intussusception (6).

In the case presented, the patient had experienced symptoms for more than a month. This subacute presentation can be explained by the intussusception causing only partial bowel obstruction and also by the intussusception being transient in nature. This transience may explain not only the occasional appearance of the abdominal pain but also why contrast-enhanced CT of the abdomen did reveal the condition, whereas colonoscopy on the previous day did not. Successful bowel preparation for the colonoscopy without causing abdominal symptoms also showed the intermittent properties of the intussusception. The colonoscopy may have played a role by reducing the intussusception via increased intraluminal pressure due to pneumocolon. However, it has been shown that intussusception can develop in the period after colonoscopy (19). The mechanisms of this phenomenon are not fully understood but may consist of hyperperistalsis of the dilated intestine preparation segment and the vacuum effect due to the suction of the endoscope at the end of the procedure (19). Endoscopic resection of intestinal lipomas is another effective way of removing small lipomas (20). However, endoscopic removal of tumors larger than 2 cm is controversial due to the higher risk of perforation or hemorrhage and should be performed only at high-volume centers (20). Due to the size of the tumor and the concurrent intussusception, we decided together with the patient to treat the condition surgically.

Surgery is the usual treatment for intussusception and is mostly performed in an emergency setting without any patient preparation. Our first case was performed in an elective fashion and in a minimally invasive manner, which allowed for faster patient recovery and better cosmetic results. The safety and efficacy of laparoscopic treatment of intussusceptions in adults has already been demonstrated by other authors, and our case supports this (21, 22). However, the surgeon performing the procedure should have appropriate technical skills and experience in laparoscopic surgery, and the patient should be in suitable condition to undergo such a procedure.

The sheer size of the intussusception seen with the second patient is also not commonly described or seen in other case reports. As is common with ileocolic and colonic intussusceptions in the adult population, the lead point was a malignant growth, and so the decision to proceed with an *en bloc* resection following all oncological principles was justified.

To conclude, we presented two cases of intussusception, one of which presented in the emergency department as acute bowel obstruction and was urgently operated on, and the other one was operated on in an elective setting due to the transient nature of the condition.

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How I Do It: Transabdominal Robot-Assisted Laparoscopic Partial Nephrectomy

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Key words

robotic surgery, partial nephrectomy, renal cell carcinoma, transabdominal approach

How I Do It

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Abstract

According to the European Association of Urology guidelines, partial nephrectomy is the treatment of choice for small renal tumors (T1a and T1b) based on functional and oncological results. Minimally invasive surgery has become the gold standard for kidney surgery. With the development of robotic surgery, robot-assisted laparoscopic partial nephrectomy is becoming a state-of-the-art choice for partial nephrectomy. It provides superior outcomes in comparison to open and laparoscopic surgery. This article reports a technique for transabdominal robot-assisted laparoscopic partial nephrectomy using the DaVinci Xi® Surgical System (Intuitive Surgical, USA) practiced at the Ljubljana Medical Centre. Initial results show that transabdominal robot-assisted laparoscopic partial nephrectomy is a safe surgical procedure, with excellent oncological and functional outcomes when performed by an experienced surgeon at a high-volume center.

Introduction

The only curative treatment for localized renal cell carcinoma (RCC) is surgery. According to European Association of Urology guidelines, partial nephrectomy is the treatment of choice for T1a and T1b RCCs (1). The surgical approach to treating renal tumor masses is moving from open to (robot-assisted) laparoscopic surgeries due to the development of new technologies and better surgical outcomes (2). The DaVinci Xi® Surgical System is used because it offers the surgeon better visualization (a stable 3D view and magnification), precise dissection and tissue manipulation, and improved ergonomics. There are two main approaches: transabdominal and retroperitoneal. The former is more widely used, especially if the patient had no previous abdominal surgeries, mainly due to better presentation of the anatomy and a larger workspace. Usage of intraoperative ultrasound and indocyanine green (ICG) diagnostics through the TilePro™ and Firefly® integrated system offers the surgeon

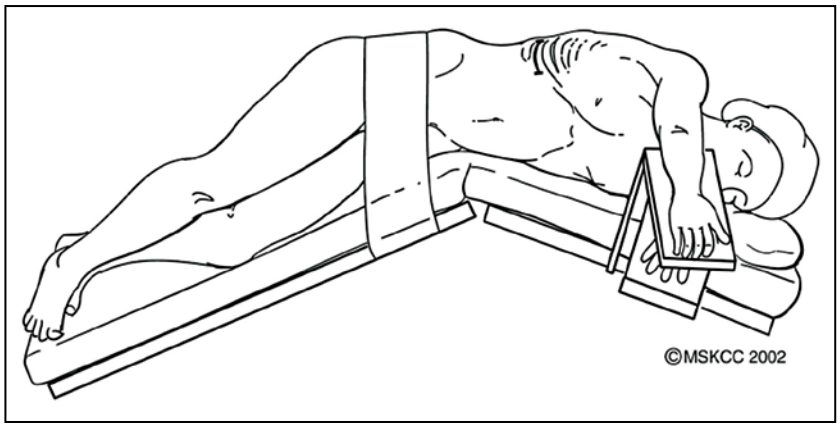


Figure 1. Lateral decubitus position (5).

additional information during the operation (3). We use the AirSeal® (Applied Medical, USA) insufflation management system, which provides stable pneumoperitoneum, constant smoke evacuation, and valve-free access, consequently achieving better results regarding operative time, shorter warm ischemia time, and more cases of "zero ischemia" (4).

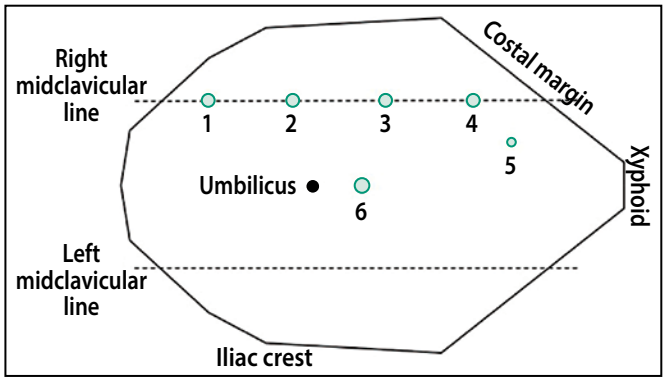
Preoperative Preparation, Positioning of Patients and Ports

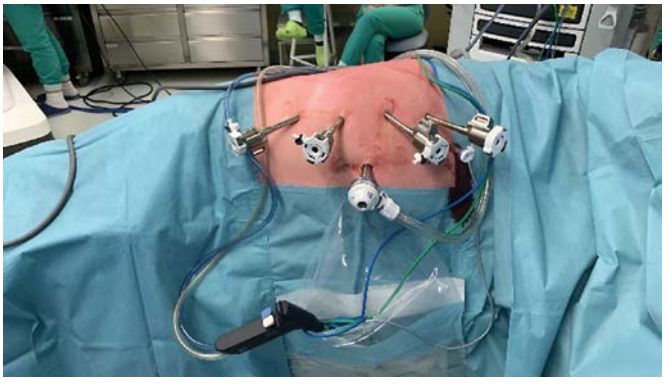
At our department, transabdominal robot-assisted laparoscopic partial nephrectomy (tRALPN) is considered a transition from laparoscopic partial nephrectomy and was therefore undertaken by two experienced urological surgeons. Multiple factors (tumor size, complexity, renal function, comorbidities, previous abdominal surgeries, etc.) are considered at interdisciplinary meetings before selecting patients for tRALPN.

Patients undergo a standard preoperative workup and preparation similar to that for conventional laparoscopic procedures, including contrast-enhanced CT of the abdomen or MRI. Before the surgery, the bowel is prepared with a single enema, and a nasogastric tube and a Foley catheter are placed for gastric and urinary decompression. Special non-slip foam is used for ensuring safety of the patient, who is placed in the lateral decubitus position (Figure 1). The operating desk is flexed as much as possible to increase the space between the lower ribs and anterior superior iliac crest. The lower extremity closer to the table is bent at the knee and hip, and the upper one remains straight.

Pneumoperitoneum of 15 mmHg is performed with a Veress needle in the umbilical region. Port positioning is in a straight line. We use a four-arm approach and one extra AirSeal® port for the assistant. On the right side, we use one more 5 mm port for liver retraction (Figure 2). The patient

Figure 2. Schematic representation of port configuration: 1. Prograsp, 2. Bipolar fenestrated grasper, 3. Endoscope (30-degree optics), 4. Scissors, 5. Liver retraction port (5 mm), 6. Airseal 12 mm assistant port (left); intraoperative port configuration (right) (personal library).





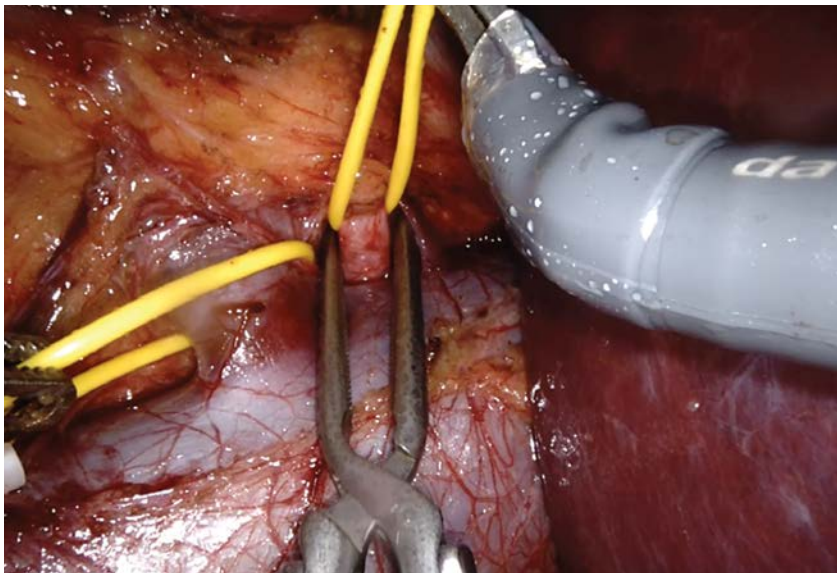


Figure 3. Vessel loop on artery (right) and vein (left) with bulldog clamping the renal artery.

cart of the robotic system is docked at the right side of the patient for right-sided kidney tumors and the left side for left-sided kidney tumors. After trocar placement, we reduce intraabdominal pressure to 8 mmHg.

Operative Steps

Step 1: Bowel Mobilization

We approach the retroperitoneal space by using monopolar scissors and bipolar fenestrated forceps. The bowel is mobilized medially using sharp and blunt dissection, thereby creating a plane between the anterior Gerota's fascia and the posterior mesocolon. It is necessary to find a relatively avascular cleavage plane between mesenteric and renal fat that is whiter in color. The bedside assistant maintains medial counter-traction. We continue dissection along the upper pole of the kidney to mobilize the spleen or liver.

Step 2: Hilar Dissection

We proceed with opening Gerota's fascia. The bowel is medially reflected to expose the gonadal vessels and the ureter. These structures are retracted superiorly, exposing the underlying psoas muscle, which is a very important landmark in kidney surgery. Dissection then proceeds toward the renal hilum. The Prograsp is used to elevate the kidney and stretch the renal hilar vessels, which are gently and precisely dissected to allow access for bulldog clamp placement. To prevent vessel damage, any unnecessary grabbing and powerful traction of the vessels should be avoided.

We put a vessel loop on the main renal artery to facilitate clamping and also on the renal vein if the case is challenging (Figure 3). Lateral renal attachments are left in place. Venous branches can be ligated or divided using bipolar electrocautery if needed for exposure.

Step 3: Tumor Exposure, Intraoperative Ultrasound, and Indocyanine Green

The next step is exposure of the tumor(s) and healthy kidney parenchyma to achieve mobility of the organ for easier excision and suturing. Gerota's fascia is opened, and the fat is cleaned off the renal capsule. The margin of resection can be marked circumferentially by using monopolar cautery (Figure 4).

A robotic ultrasound probe is used to determine the location and size of the endophytic renal tumor(s). We use Hitachi Aloka, a real-time robotic endoscopic drop-in ultrasound probe, which allows wrist articulation of the robotic instruments and imaging even at complex angles that is not possible with conventional laparoscopic ultrasound (6). This enhanced range of motion allows surgeons to identify tumor(s) location more accurately, as well as depth and borders for distinguishing between tumor and normal kidney (Figure 5). A color Doppler may be used to

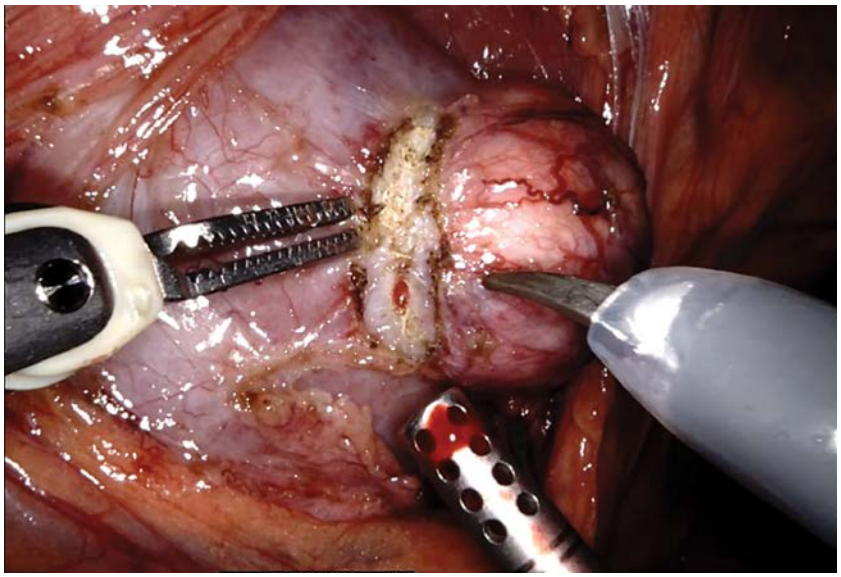


Figure 4. Tumor exposure, margin of resection.

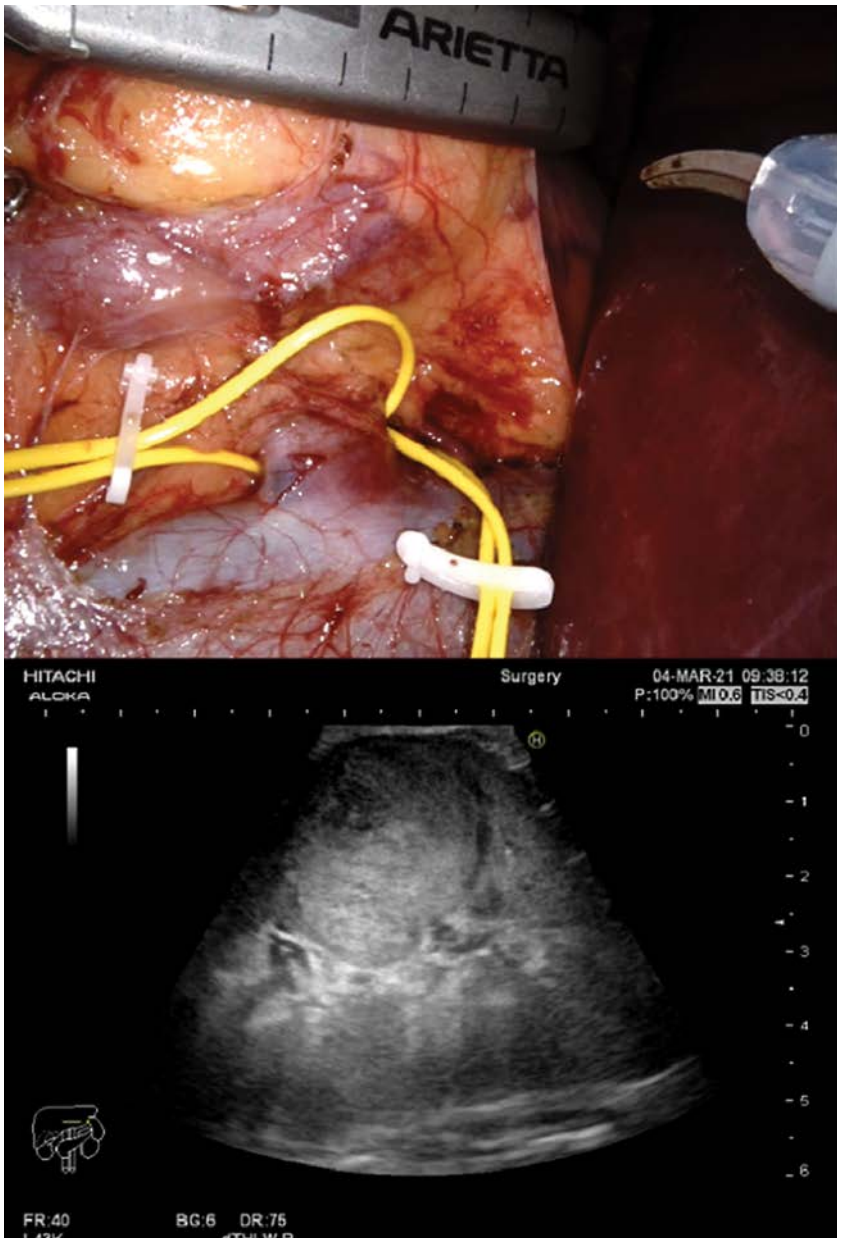


Figure 5. Intraoperative ultrasound with robotic endoscopic drop-in ultrasound probe.

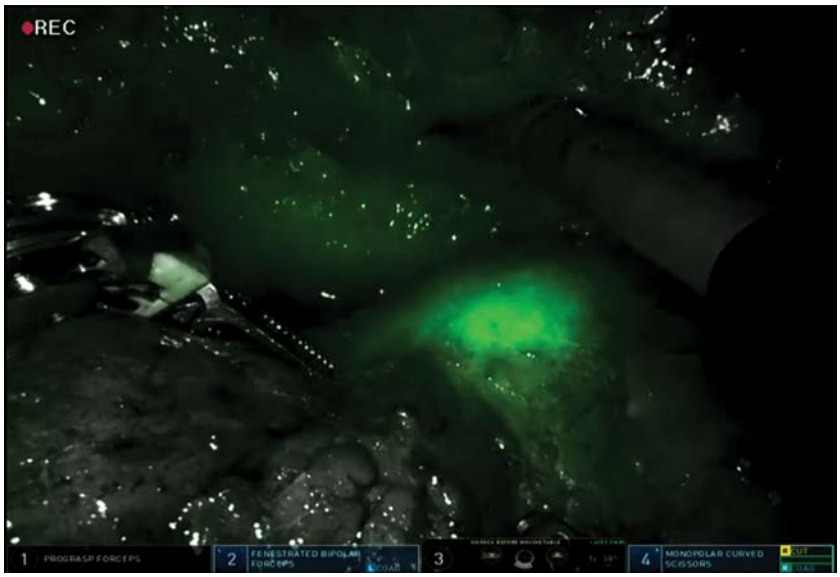


Figure 6. Indocyanine green showing areas of different perfusions.

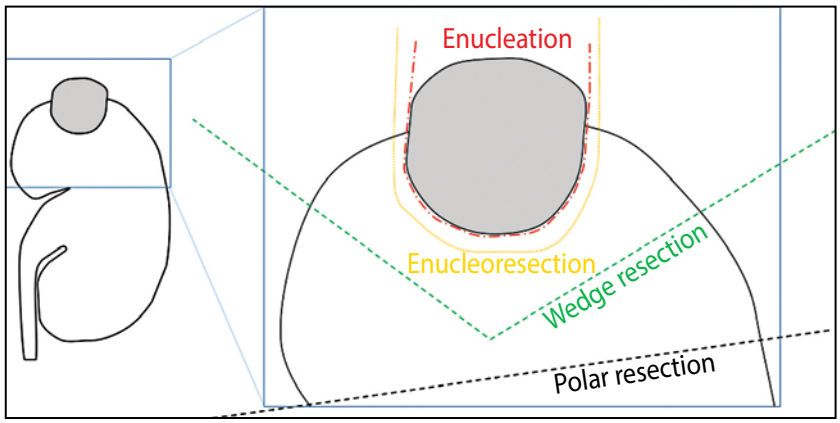


Figure 7. Different types of partial nephrectomies.

identify adjacent vessels and assess perfusion after clamping.

Similarly, ICG appears as a useful tool in tRALPN due to real-time identification of renal masses, renal vasculature, and the renal mass parenchymal margin (7). Administration of ICG facilitates selective clamping of the tumor-specific branch of the renal artery, which significantly reduces warm ischemia time of healthy renal parenchyma, which may lead to preservation of renal function. We can also use it to assess the perfusion of the kidney after removal of hilar tumors and closure of the tumor defect (Figure 6).

Step 4: Hilar Clamping, Tumor Excision, and Renal Reconstruction

After precise observation of the CT scan or MRI and assessment of tumor vascularization, the decision is made 1) not to clamp, 2) to clamp the main artery or only the segmental one, or 3) to clamp both the main artery and vein. The assistant clamps the renal hilar vessel(s) using laparoscopic bulldog clamp(s) through the 12 mm AirSeal® assistant port (Figure 3). We clamp the renal hilar vessels using separate bulldog clamps for the renal artery and renal vein. We do not use mannitol before clamping.

There are several subtypes of partial nephrectomy (Figure 7). The immediate peritumoral edge is an anatomically favorable surgical plane. Enucleative partial nephrectomy is histologically safe because most RCCs (82%) have an intrarenal pseudocapsule (8). However, we have to be very careful to avoid positive margins because 28 to 33% of pT1a RCCs have a neoplastic invasion of the pseudocapsule (8, 9).

The tumor is resected along the previously scored margin with the robotic monopolar scissors (Figure 4). The fenestrated bipolar grasper is used to

manipulate the tumor for exposure and to aid in dissection. Prograsp helps in positioning the kidney to the preferred position for excision and suturing. The assistant uses suction to expose and sustain adequate visualization of the resection plane of the tumor. After excision, the tumor can be placed 1) beside the kidney, 2) on top of the liver for later retrieval, or 3) in the retrieval endobag.

Hemostasis is achieved using a combination of cautery, 5 mm titanium clips, and suturing. Scissors are changed for a robotic needle driver. A 3/0 Monocryl running suture is used to achieve hemostasis and repair any previously identified entry into the collecting system. This step also helps minimize the development of pseudoaneurysm postoperatively. Sutures are secured with Hem-o-lok® clips and locked with LAPRA-TY® clips. After inner renorrhaphy, we unclamp the renal artery (early unclamping) in the majority of cases. Hemostasis is confirmed, and then a renal parenchymal defect is approximated using interrupted Vicryl 0 sutures and compressed (Hem-o-lok® sliding technique; Figure 8).

Hemostatic agents are rarely used. The kidney is placed back in its anatomical position and perirenal fat is sutured over the exposed kidney parenchyma with Vicryl 0 running suture ("retroperitonealization"). The specimen is placed in a retrieval endobag and removed through the primary assistant AirSeal® 12 mm port, enlarging the port site if needed, or through the most caudal robot port if the tumor is larger than 3 cm. A drain is placed in the abdominal cavity. At the end, we suture the muscles and skin incisions.

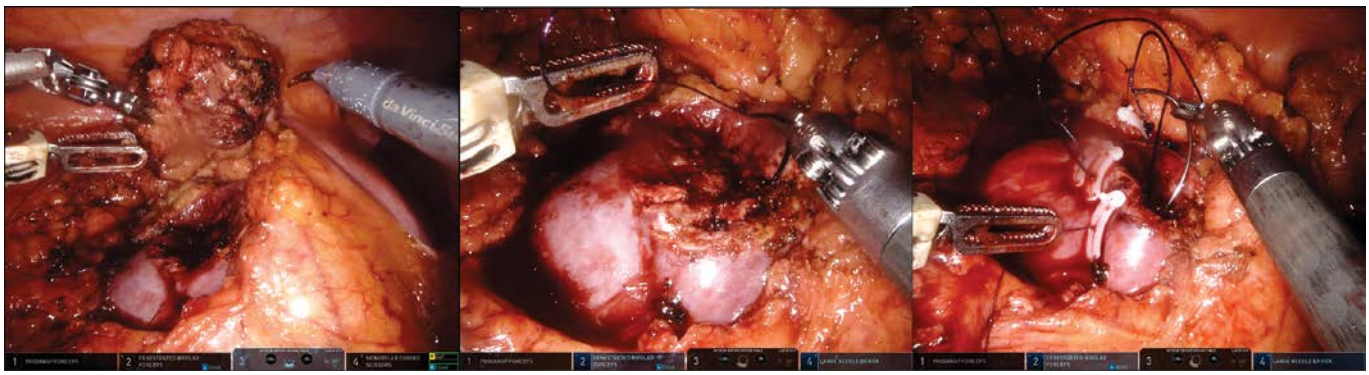
Postoperative Care and Follow-Up

Before the end of the surgery, the nasogastric tube is removed. We remove the drainage tube and Foley catheter on the 1st postoperative day. In the evening after the surgery, we offer clear liquids to patients that do not show nausea or vomiting, who are quickly advanced to a regular diet. In general, patients are discharged on postoperative day 3. Early and frequent mobility is encouraged, and venous thromboembolism prophylaxis is continued for 30 days after the surgery. The first outpatient visit is 3 to 6 months after the surgery and consists of a history assessment and physical examination, abdominal ultrasound, chest X-ray, and blood work, including electrolytes. The additional follow-up interval depends on the tumor characteristics, but it mostly includes outpatient visits every 6 to 12 months.

Conclusions

At the Ljubljana Medical Center our team started using the DaVinci Xi® robotic platform in June 2018 and had performed 100 tRALPN procedures as of August 2021. To date, the technique reported in this article has proved to be very successful. After a median follow-up of 20 months, we observed no tumor recurrence, no conversions to open procedures, no urinary leakage, and no decrease in renal function postoperatively. The median warm ischemia time was 16 minutes. We observed two major complications, two conversions to radical nephrectomy, and a positive surgical margin in

Figure 8. Renal parenchymal defect after excision of the tumor (left). Inner renorrhaphy (middle). Outer renorrhaphy (right).



one case. The average length of stay was 3 days. Our results are comparable with the literature. Adherence to key technical principles is critical for the best clinical outcomes of surgery. We believe that tRALPN is a safe surgical technique with excellent functional and oncological outcomes when performed by an experienced surgeon at a high-volume center.

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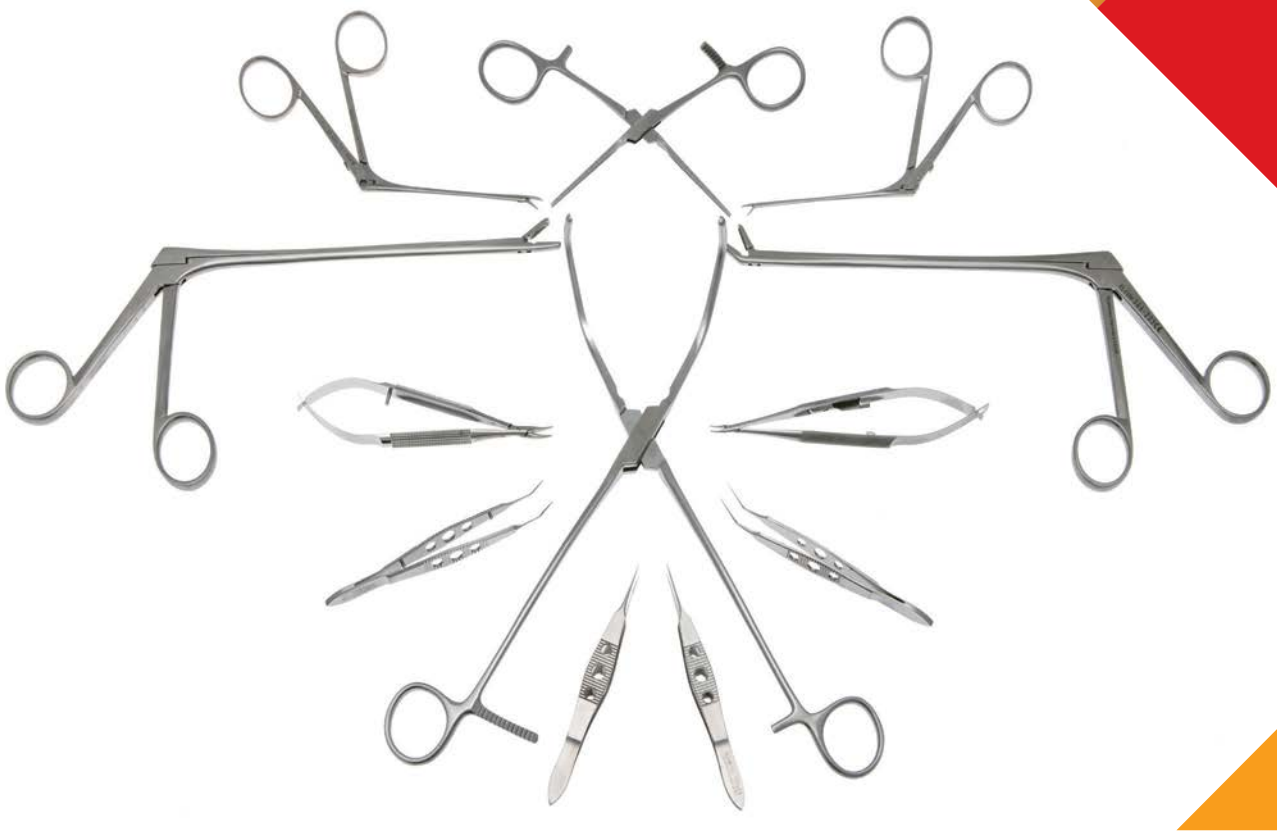

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Study Protocol: Laparoscopic Gastrectomy Guided with a Markerless Non-rigid Framework and Augmented Reality (LAMAR Study)

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Key words

laparoscopic gastrectomy, splenic hilum, augmented reality

Study Protocol

SURGERY SURG ENDOS 2021; 3(2): 49-54

Abstract

Background. The most complex stage during laparoscopic gastric cancer surgery is dissection of the splenic hilum. The surgeon has to work in a small operative field with limited visibility without the sense of touch. In order to compensate for the lack of touch and the limited field of view restricting laparoscopic operations, we will supplement laparoscopy with augmented reality. In the process we will develop a computer system that will effectively generate a 3D mesh of organs from stereoscopic images and align them with high-resolution 3D models of organs from preoperative images. The algorithm will recognize the differences of the organ positions that result from tissue manipulation during the operation.

Methods. Patients with gastric cancer of the middle and lower third of the stomach will be examined with CT angiography. A preoperative 3D rendering of vascular and tissue structures will be obtained. The patients will be operated on laparoscopically with a 3D stereo camera. Preoperatively generated 3D organ renderings will be aligned on the intraoperative stereo images. On the generated virtual image, we will determine the anatomical topographic landmarks that will be the basis for tracking the non-rigid model. This model will track the changing position of the organs caused by intraoperative tissue manipulation. The computer image will be projected on the surgical field in real time. We will determine the deviation of the position of the target structures between the operative field and the computer-generated virtual image of organs and vessels. We will compare the duration of surgery, the amount of blood loss, and the number of lymph nodes dissected between augmented reality–guided and laparoscopic surgery.

Conclusion. We will show that it is possible for virtual 3D organ models to precisely predict the location of target anatomical structures. We will show that our model can follow the changes that occur during the operation because of tissue deformation due to manipulation. We will show that computer algorithms can detect and follow surface changes of the target organs. We will show that augmented reality–guided surgery is safer compared to laparoscopic surgery, produces less blood loss, makes possible faster operating times, and allows extraction of more lymph nodes.

Introduction

Successful surgery is determined by correct identification of structures that can be safely divided and structures that are vital for the patient and should be preserved. Therefore, good identification of individual anatomical features is one of the key elements of safe surgery. Laparoscopy presents a greater challenge. During open surgery, the surgeon can rely on numerous senses to dissect tissue structures. He can feel the pulsations of vessels that are otherwise hidden, and the operating field is larger in open surgery. During laparoscopy the surgeon has weakened sensation in his hands and has a limited field of view. Laparoscopic gastric cancer surgery is known to be one of the most demanding laparoscopic procedures. In laparoscopic gastrectomy the surgeon has to dissect lymphatic structures away from vessels. This procedure is known as lymphadenectomy. The most complex stage of lymphadenectomy during laparoscopic gastrectomy is lymphadenectomy of the splenic hilum. The area where the splenic arteries enter the spleen is anatomically very challenging. In addition, this region contains lymph nodes that can be involved in up to 20% of upper and middle third gastric cancers (1). If these lymph nodes are not removed during surgery, they can be the source of cancer recurrence (2). Unfortunately, the splenic artery has many anatomical variations (1–5). The splenic artery can run toward the spleen on the upper border of the pancreas or behind the pancreas, or it can be deeply buried in the pancreatic parenchyma (6, 7). The artery can run in front of or behind the splenic vein (1–7). The splenic artery can divide into terminal arteries before it enters the spleen. All these variations can be additionally complicated by additional individual distinctiveness. Not only must the surgeon be aware of distinct variations, but he also has to acknowledge the proximity of other organs. The splenic arteries are often hidden between the tail of the pancreas, fatty tissue of the retroperitoneum, and the left suprarenal gland. The former structures are very delicate and fragile, and they can be the source of devastating intraoperative or postoperative bleeding. Bleeding from splenic arteries is especially difficult to control during the operation due to great blood flow in them, limited visibility, and fragility of the spleen itself. Preoperative diagnostic imaging can help the surgeon avoid vascular injuries. Although preoperative imaging can identify tissue structures, these images are two-dimensional. Modern application software can help with 3D rendering of 3D models; however, neighboring structures are usually missing in the final render, and the smallest structures are not identified. Another major obstacle is the rigid nature of these 3D renderings, which do not follow tissue manipulation during surgery. The lack of the sense of touch and the limited field of view that restricts laparoscopic operations will supplemented by augmented reality. Augmented reality will provide the surgeon with an overlay image of the operating field during the operation in real time and make the procedure faster, more efficient, and safer. In the process, we will develop a computer system that will effectively generate a 3D mesh of organs from stereoscopic images and align them with high-resolution 3D models of organs from preoperative images. The algorithm will recognize differences in the organ positions resulting from tissue manipulation during the operation. The main aim of the proposed project is development of a new augmented reality system for laparoscopic gastrectomy and implementation into clinical practice. Therefore, the overall aim is specified by the following objectives:

- Objective 1: to develop an algorithm that will align 3D models of the organs from preoperative radiological images to the organs on stereoscopic images;
- Objective 2: to prove that augmented reality–guided surgery is safer compared to laparoscopic surgery because it can determine the position of hidden critical structures such as vessels to prevent their injury;
- Objective 3: to prove that augmented reality–guided surgery is more precise with regard to the number of lymph nodes extracted;
- Objective 4: to use the final algorithm for augmented reality–guided pancreatic and liver operations; and

- Objective 5: to translate the algorithms to other platforms (i.e., Microsoft HoloLens) and other fields of surgery such as vascular surgery, urological surgery, and orthopedic surgery.

In the scope of the proposed project, the following hypotheses will be examined:

- Hypothesis 1: With the use of fixed anatomical topographic landmarks, it is possible to obtain an exact alignment between the 3D renderings and the intraoperative organ positions obtained from the 30-degree stereoscope with a deviation of less than 1 mm.
- Hypothesis 2: With the determination of anatomical topographic landmarks, it is possible to track the positional changes of the 3D renderings and the target structures with an error of less than 1 mm.
- Hypothesis 3: The method of markerless tracking allows determination of the position of the target organ or target vessel, which corresponds to the actual intraoperative image with an error of less than 1 mm.
- Hypothesis 4: Augmented reality–guided surgery allows a better lymphadenectomy with an average yield of 10 lymph nodes more compared to laparoscopy.
- Hypothesis 5: Augmented reality–guided surgery reduces intraoperative blood loss by 200 ml.
- Hypothesis 6: Augmented reality–guided surgery reduces operating times by 20 minutes.

Methods

Our system will be based on stereoscopic images of the operative field and on computer tomography data. The entire method will be based on a generic augmented reality pipeline in laparoscopic surgery (8–19). Computer tomography data will be used to generate a 3D model of the organ. At the same time, we intend to generate a 3D mesh from stereoscopic operative images in real time and to perform real-time non-rigid 3D model alignment with the organ on operative images, as shown in Figure 1. For identification of the target organ, we will introduce a new markerless approach. We intend to use clearly visible anatomical landmarks such as organ edges, color differences, and light and contrast differences for organ recognition.

We will pay special attention to the following challenges that have not yet been clearly solved in related studies. Soft tissues and the changing position of organs make alignment difficult (20–23). The laparoscopic images also have different lighting conditions and are corrupted by noise, all of which makes the development of new algorithms necessary. The entire process will be com-

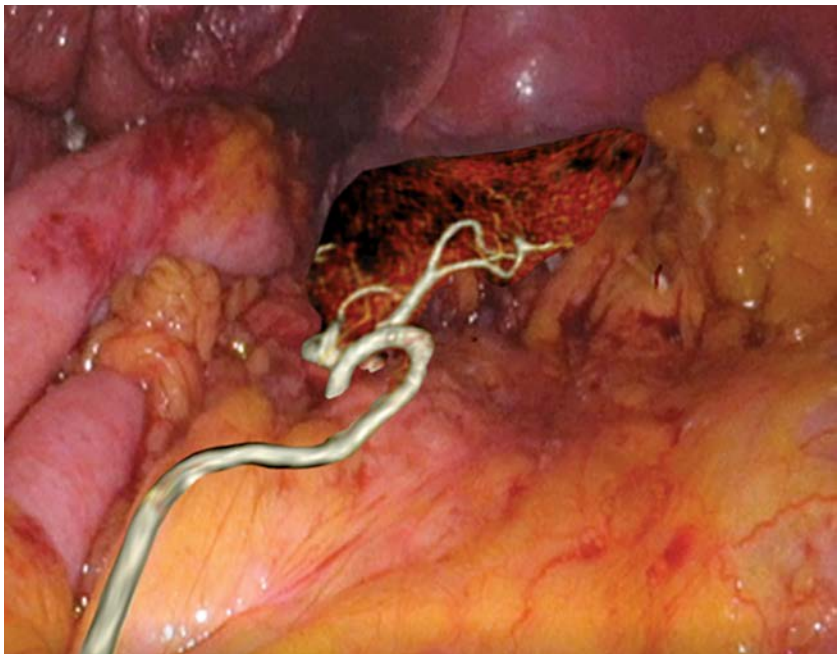

Figure 1. A conceptual design example of augmented reality–guided surgery, showing a computer-mapped 3D reconstruction of the splenic artery from tomographic images over a laparoscopic image.

putationally complex; therefore, special attention will be devoted to the implementation of efficient computer algorithms.

Our method is very promising because it will allow the automatic recognition of organ surfaces from stereoscopic images without additional hardware, external markers for organ tracking, and manual intervention. The final algorithm will be exceedingly flexible because it will detect tissue deformation during intraoperative manipulation. The algorithm will be designed to work in real time and to continuously track operative field changes with a sufficient refresh rate to be applicable during the operation. This will provide an exact alignment of the virtual 3D models and the operating field, providing the surgeon with an advantage in detecting dissecting tissues and consequently a safer operation.

The aim of our study will be to generate a non-rigid markerless model of organs that will make laparoscopic operations safer. The lack of the sense of touch and the limited field of view that limit laparoscopic operations will be compensated for or supplemented by augmented reality. Augmented reality will provide the surgeon with an overlay image on the operating field during the operation in real time and make the procedure faster, more efficient, and safer. In the process, we will develop a computer system that will effectively generate a 3D mesh of organs from stereoscopic images and align them with 3D models of organs from preoperative images. The algorithm will recognize the differences in the organ positions that result from tissue manipulation during the operation. We will thus create a virtual landscape for the surgeon. We will validate the system by determining the errors of the alignments between the virtual and the operating field organ positions. We will verify the effectiveness of augmented reality–guided surgery compared to laparoscopic surgery by measuring the duration of the operation, blood loss, conversion rate, and complications. In this manner we will objectively determine the benefits of augmented reality–assisted laparoscopic surgery. As the parameter for ontological efficiency, we will compare the number of lymph nodes extracted between augmented reality–guided and laparoscopic surgery. Finally, we will transfer the fully developed system to other surgery platforms. The study design is shown in Figure 2.

Patients with histologically verified gastric cancer of the middle and lower third of the stomach intended for total or subtotal laparoscopic gastrectomy will be included in the study. Before surgery, every patient will be examined with a CT angiography with MIP and the MRP protocol with 1 mm tissue slices providing an exact vascular anatomy of the splenic arteries and their relation to neighboring soft tissue structures. A preoperative 3D rendering of vascular and tissue structures will be obtained. The patients will be operated on laparoscopically. For laparoscopy we will use a 30-degree 3D laparoscope with a stereo camera. Preoperatively generated 3D organ renderings will be aligned on the intraoperative stereo images. On the generated virtual image, we will determine the anatomical topographic landmarks that will be the basis for tracking the non-rigid model. This model will track the changing position of the organs caused by the intraoperative tissue manipulation. The computer image will be projected on the surgical field in real time, where we will determine the deviation of the position of the target structures between the operative field and the computer-generated virtual image of organs and vessels.

We will compare the number of lymph nodes dissected between augmented reality–guided and laparoscopic surgery. We will compare the duration of surgery, the amount of blood loss, and complication rates between augmented and laparoscopic surgery. In the final step, we will apply our solutions to different platforms in other fields of surgery.

Discussion

Our project will have a revolutionary impact on the development of laparoscopic surgery for gastric cancer. Because of easier recognition of crucial structures, the project will help with the introduction of minimally invasive surgery for gastric cancer. Augmented reality–guided surgery will decrease the morbidity and mortality rates of surgery because it will make tissue dissection more precise and reduce unnecessary tissue trauma. The surgeon will dissect more lymph nodes, which will eventually lead to better long-term survival. Because of faster recovery and better functional results, we expect that augmented reality will eventually change the current guidelines for gastric cancer.

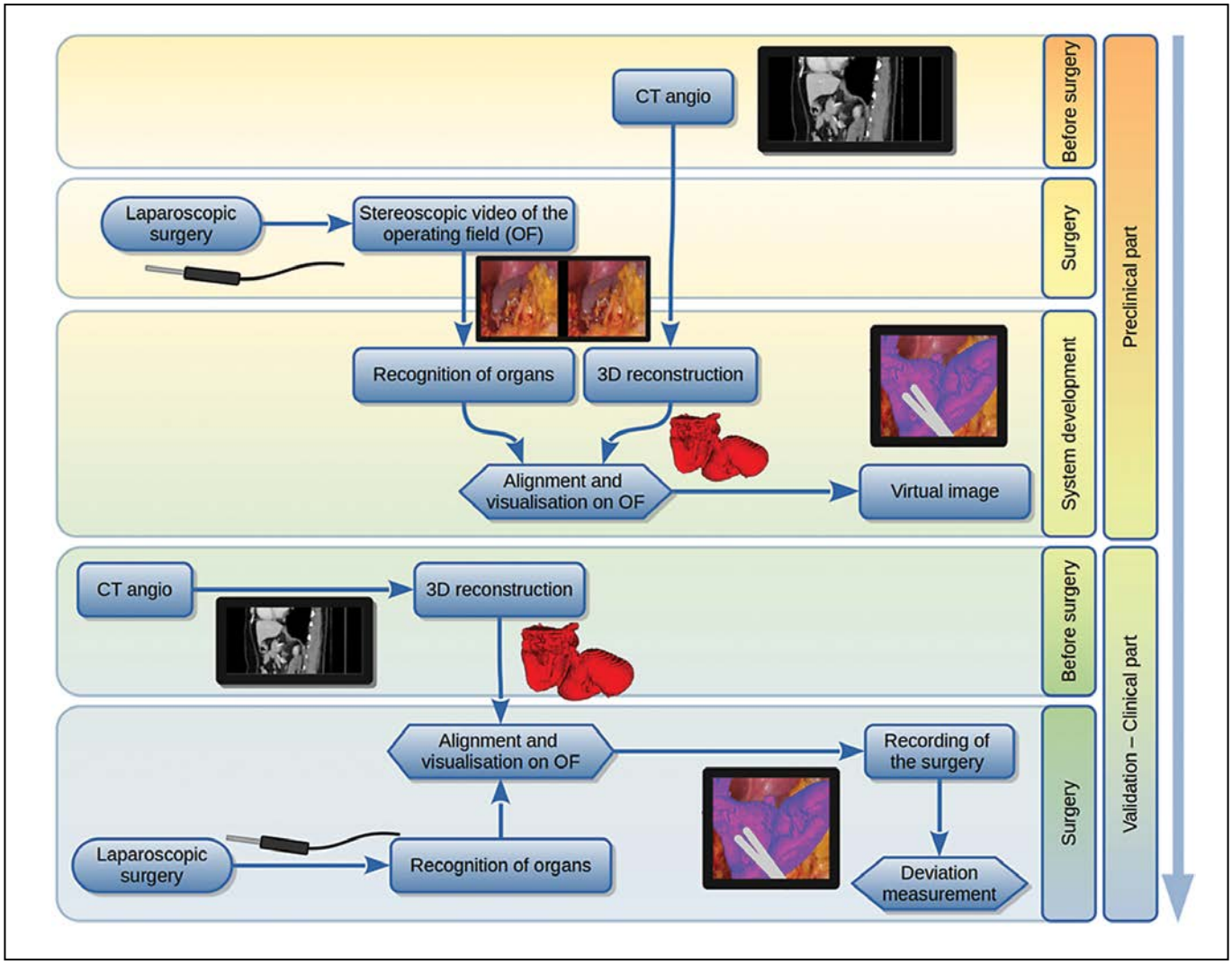

Figure 2. Workflow of the proposed project.

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The Effect of Sarcopenia and Myosteatosis on the Outcome of Adhesive Small Bowel Obstruction: A Study Protocol

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Key words

sarcopenia, myosteatosis, malnutrition, adhesive small bowel obstruction, skeletal muscle area, muscle attenuation

Study Protocol

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Abstract

Background. Patients with adhesive small bowel obstruction often have multiple risk factors for developing malnutrition. Malnutrition has been associated with complications in surgical patients; however, the role of malnutrition in adhesive small bowel obstruction is not known. The workup of these patients includes a CT scan of the abdomen, which allows us to measure skeletal muscle area and muscle attenuation and permits us to recognize malnutrition in the form of sarcopenia and myosteatosis. We present a protocol for a study to facilitate understanding of the role of malnutrition in adhesive small bowel obstruction.

Methods. We will prospectively enroll patients that are admitted to the surgical ward due to adhesive small bowel obstruction and have a CT scan of the abdomen performed at admission. We will analyze the CT images at the L3 level to measure skeletal muscle area and muscle attenuation to determine the extent of sarcopenia and myosteatosis, respectively. If the patients are operated on, we will grade the extent of adhesions intraoperatively. After the operation, we will follow the patients to grade the postoperative complications. We will compare the need for operative treatment, the peritoneal adhesion index, and the rate of complications between patients with sarcopenia or myosteatosis and patients without them.

Conclusion. A better understanding of the role of malnutrition will help indicate whether we should try nonoperative management or operate on these patients sooner. Malnutrition might also play a role in the formation of adhesions, with malnourished patients having fewer dense adhesions.

Introduction

Adhesive small bowel obstruction (ASBO) is the most common form of mechanical bowel obstruction, and it is estimated that 300,000 patients are hospitalized every year in the United States due to this condition (1, 2). Adhesions may form after previous

operations, radiation therapy, or inflammatory diseases, and they may reoccur after adhesiolysis (3). ASBO can be treated operatively, but it may also resolve nonoperatively in 70 to 90% of cases (4, 5). Operative treatment is not the ideal treatment modality due to recurrence of the adhesions and possible complications of surgery. If there are no risk factors for expecting failure of conservative treatment, it is recommended to begin with nonoperative treatment with a decompressive nasogastric tube and complete bowel rest. Among the risk factors are elevated body temperature, tachycardia, elevated inflammatory markers, acidosis, clinical signs of abdominal guarding, high losses through the nasogastric tube, collapsed colon on imaging, and absence of improvement of pain (6). Contrast-enhanced CT (CECT) can help with the decision to operate or not, but it is not always necessary to perform this (6).

Patients with ASBO often have several risk factors for developing malnutrition because they have often had previous abdominal operations. Adhesions may also manifest in chronic nausea, abdominal pain, and quick satiety (7). The acute presentation and conservative treatment of ASBO lowers the intake of nutrients and can worsen malnutrition (4, 7). Malnutrition may play a negative role in resolution of ASBO, and it is the goal of our study to test this hypothesis.

The role of malnutrition on the formation of adhesions is also not known. Malnutrition might be a protective factor that reduces the formation of adhesions due to compromised collagen synthesis and other factors that inhibit wound healing in general (8). Malnutrition is also associated with more postoperative complications, and in general it is recommended to improve the nutritional status whenever feasible before a major operation (9, 10).

Malnutrition can be assessed by measuring body composition, which can be performed in a number of ways, including bioelectrical impedance analysis and dual energy X-ray absorptiometry (11). One of the most accurate ways is by measuring this with radiological imaging, such as CECT or MRI, which can reveal sarcopenia and myosteatosis. Sarcopenia is defined as loss of quality and volume of muscles, and myosteatosis is the infiltration of muscles with fat (12). They are most commonly measured using axial images of abdominal CECT at the level of the third lumbar vertebra (13).

We present a protocol for a study to measure the association between malnutrition and the need for operative therapy of ASBO, the extent of adhesions, and the number of postoperative complications.

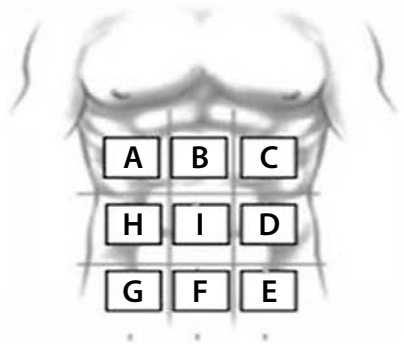
Methods

From July 2020 to December 2021 we will gather data from patients that present with ASBO and are admitted to a surgical department at a tertiary center. We will include patients that have a CT of the abdomen performed within 48 hours of admission and are managed operatively or nonoperatively. Inclusion criteria include dilation of small bowel loops by more than 3 cm but absence of dilation of large bowel loops by more than 6 cm or 9 cm in the cecal area. Patients with other intraabdominal pathology or bowel obstruction that is due to causes other than adhesions will be excluded, such as tumors, carcinomatosis, incarcerated hernia, bowel intussusception, foreign body, volvulus, intramural hematoma, ischemia, bowel perforation, trauma, or inflammatory diseases, as will patients that underwent an abdominal operation in the last 6 months before readmission.

We will exclude patients that need to be urgently operated on, such as patients with suspected bowel ischemia on CECT, elevated lactate levels, closed loop obstruction, or signs of systemic inflammation such as elevated body temperature, CRP levels above 100 mg/l, or elevated leukocytes above 15 × 10^9/l. Patients with inflammatory bowel diseases, patients that have had an abdominal operation in the last 6 months, and patients with malignant diseases that are not in remission or that required treatment in the last 6 months will also be excluded.

The prospectively collected data will include patient characteristics such as age, sex, inflammatory markers, ASA score, BMI, weight loss in the last month before admission, comorbidities, previous abdominal operations, or radiotherapy treatments. Every surgeon will grade the degree of adhesions during the operations using the peritoneal adhesion index (Figure 1) (7, 15–17). The length of the operations will also be measured, as well as postoperative events including the duration of hospitalization, complications, and Clavien–Dindo score (14). The data will be collected for 1 month after the operation. Our radiologist will measure sarcopenia on CECT using the skeletal mass index (SMI) at the level of the third lumbar vertebra, and myosteatosis will be measured from muscle attenuation (MA) at the same level using ABACS software

Peritoneal Adhesion Index:



Regions:		Adhesion grade:
A	Right upper	_____
B	Epigastrium	_____
C	Left upper	_____
D	Left flank	_____
E	Left lower	_____
F	Pelvis	_____
G	Right lower	_____
H	Right flank	_____
I	Central	_____
L	Bowel to bowel	_____
PAI		☐

Adhesion grade score:

- **0** No adhesions
- **1** Filmy adhesions, blunt dissection
- **2** Strong adhesions, sharp dissection
- **3** Very strong vascularized adhesions, sharp dissection, damage hardly preventable

Figure 1. Peritoneal adhesion index estimated during the operation (17).

(Automated Body composition Analyzer using Computed tomography image Segmentation) (13).

After gathering the data, the patients will be divided into two groups depending on whether they were operated on or not. Both groups will be compared by SMI, MA, age, sex, ASA score, BMI, and whether there was weight loss. Sarcopenia will be defined as SMI less than 43.1 cm^2/m^2 in men or less than 32.7 cm^2/m^2 in women. Myosteatosis will be defined as MA less than 30.9 HU (Hounsfield units) in men and less than 24.8 HU in women (13).

Operated patients will also be divided by SMI and MA grade, and this will be correlated with postoperative complications, grade of adhesions, operative time, and duration of hospitalization.

Our study has been approved by the Slovenian National Medical Ethics Committee (approval number 0120-274/2020/3).

Discussion

This will be the first study to investigate the effect of sarcopenia and myosteatosis on the need for surgical treatment, the degree of adhesions, and postoperative complications of ASBO. An important benefit of the study is a large volume of ASBO patients at a single center with prospectively collected data.

The effect of malnutrition on the need for surgical treatment is difficult to predict. On the one hand, patients with malnutrition might have a paralytic component to their ASBO, which can contribute to slow resolution or non-resolution of the disease, which can be caused only by partial bowel obstruction, and all of this could result in a higher rate of operation. On the other hand, conservative efforts including parenteral hydration/nutrition and the correction of electrolytes could be effective in these patients for recovering the state of bowel obstruction, and this could lead to lower rates of operative treatment. If malnutrition is associated with fewer adhesions due to the lower capacity for scar tissue formation, it could also be associated with fewer operations.

However, patients that will require operative treatment and have signs of malnourishment on CECT might have higher postoperative morbidity. It is these patients that profit the most from nonoperative treatment and for whom we should persist longer before operating. This, however, could be a double-edged sword because the patients' state will worsen with immobility and insufficient nutritional input.

Another aspect that should be acknowledged in the future is how surgical treatment affects the quality of life in these patients and how it affects the number of recurrences of ASBO in patients with malnutrition.

Conclusion

ASBO is the most common form of bowel obstruction and is mostly treated nonoperatively. We believe our study will reveal whether patients with ASBO and sarcopenia or myosteatosis should be operated on sooner or not.

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IX. Slovenian Symposium on Hernias with International Participation

Main Topic

Laparoscopic Repair of Ventral Hernias and Rectus Diastasis

Organizers:
University Medical Center Maribor and
Slovenian Hernia Society

Teaching Courses for Transversus Abdominis Release: Experience from Hospitals in Slovenia, 2015–2020

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IX. Slovenian Symposium on Hernias

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Abstract

Introduction. Patients with very large incisional hernias (transverse defect > 8–10 cm) are not very numerous. Few surgeons master the techniques to close such hernia defects and restore the biomechanical function of the abdominal wall in an optimal way. To achieve this, sublay (Rives–Stoppa) with transversus abdominis release (TAR) has been proposed in recent years as a method of choice to close hernia defects with large diameters. The ways of learning such a complex hernia repair technique may be very different; among them, the most important is experience in the sublay technique and support services in the hospital (anesthesiology, intensive care unit, pain control, radiology, botulinum toxin A application possibility, and hernia registry).

Methods. Thirteen years of biennial Slovenian hernia symposia and workshops (2008–2020) on modern hernia topics have resulted in a certain paradigm change in the daily practice in general hospitals, and so a questionnaire was sent to 11 surgical departments in Slovenia to assess the expected results. To define hospitals that may perform complex hernia surgery in the future, TAR hands-on workshops and courses have been held at nine Slovenian hospitals in the last 6 years (2015–2020). The TAR technique was demonstrated and assisted local surgeons with their own patients with very large incisional hernias.

Results. Sublay hernia repair and TAR component separation techniques were introduced at Slovenian hospitals in 2012 and 2016, respectively, which has resulted in a partial paradigm change (accepting these methods as gold standards). An illustrated book on the TAR technique was published in 2016. Ten patients with hernia defects with a transverse diameter > 10 cm were successfully operated on at nine Slovenian hospitals as mentoring and assisting operations for experienced local surgeons.

Conclusion. Learning TAR under the supervision of an experienced surgeon is safe and can be a recommended method for hernia surgery education. However, the learning curve is long. Due to TAR complexity and the high incidence of complications, the TAR technique should not be performed at every hospital. The conditions of sufficient surgical expertise, expected patient volume of minimally 10 TAR/year, and a pre-/postoperative multidisciplinary approach should be fulfilled.

Introduction

Large meta-analyses estimate the overall incidence of incisional hernia at 12.8% (1). The exact incidence of incisional hernia is unknown and shows great variety (10–30%) (2). The reasons for this should be found in different operative approaches in the primary operation (laparoscopy, laparotomy), different methods of laparotomy closure, comorbidities of the patients, and their body mass index (3). The majority of symptomatic patients come to surgeons by themselves. However, a certain percentage of patients are asymptomatic and thus not aware of their hernia and its effects (2, 3). An indication for surgery in incisional hernia is always reasonable because incarceration as the most severe complication is estimated to occur in 6 to 15% of patients with incisional hernia (4). Another result of surgery is significantly improved quality of life after surgery in at least three parameters: better movement restriction, less fatigue, and an improved visual analogue pain scale (VAS) score (5). The incidence of incisional hernia in Slovenia is similar to that in other European countries: a midline incision is predominantly used for bowel and other abdominal operations, which results in a rather higher incisional hernia incidence compared to transverse laparotomies (6, 7). Incisional hernia repair should include mesh repair nowadays. It is predominantly performed as open surgery, but also laparoscopically (2, 8). Based on the good long-term results and relatively uncomplicated surgical technique of the sublay technique, presentations and live surgery performed by Andrew Kingsnorth (sublay, 2012) and Rene Fortelny (TAR, 2016) were landmarks for proposing both techniques as methods of choice for (large) incisional hernias at Slovenian hospitals (9, 10).

Methods

A questionnaire about the preferred surgical technique for incisional hernia was sent to chief surgeons at 11 hospitals across Slovenia (two medical centers and nine general hospitals). It is unknown to what extent education during hernia symposia and hernia workshops influenced the daily practice of surgical departments in the past. Subsequently, nine TAR hands-on workshops were held at seven Slovenian hospitals from 2015 to 2020, in which 10 patients with very large incisional hernias (transverse diameter > 10 cm) were operated on using the TAR technique. The operations were assisted by experienced hernia surgeons in a mentoring process.

Results

Data on the techniques for incisional hernia at 11 hospitals are presented in Table 1.

Between 2015 and 2020, nine TAR workshops were performed as lectures and hands-on mentoring surgery at one medical center and six general hospitals in Slovenia. The location of the hospitals and workshop agenda are presented in Figure 1 and Table 2.

Between 2015 and 2020, the TAR technique was introduced at nine hospitals (one clinical center and eight general hospitals) in Slovenia. For this purpose, an illustrated book on the TAR technique was published by the Slovenian Hernia Society to make the technique more accessible (Figure 2).

All operations were mentored (and assisted to a variable extent) for local surgeons. The shortest operation took 3 hours and the longest 6 hours. Mesh sizes of up to 45 × 45 cm were used. Preoperative preparation of the patients included 300 I.U. of botulinum toxin A (BTA) application in four patients (40%). Only two patients had postoperative complications (one skin dehiscence on day 5, which was treated with a vacuum sealing device for 2 weeks, and one patient developed a large seroma that was evacuated by aspiration three times in the weeks following the operation and conservatively further on). No patient has had a recurrence after the TAR operation to date (1–5 years postoperatively). Figures 3, 4, and 5 present patients before and after bilateral TAR after BTA application.

Table 1. Development of surgical techniques for incisional hernia at 11 hospitals in Slovenia. The most-performed (preferred) techniques are in capitals; * = sublay routinely performed since 2007; ** = sublay routinely performed since 2004; X = no data.

	Mesh position		Component separation	
	Before 2012	After 2012	Before 2016	After 2016
Medical center 1	ONLAY, ipom, sublay	SUBLAY, ipom, onlay	IPOM, Ramirez	TAR, ipom
Medical center 2	IPOM, onlay	SUBLAY, ipom, onlay	IPOM, Ramirez	TAR, ipom
General hospital 1	ONLAY, ipom	SUBLAY, ipom, onlay	RAMIREZ, ipom	TAR, Ramirez
General hospital 2	IPOM, onlay	SUBLAY, ipom	X	X
General hospital 3	SUBLAY*, onlay	SUBLAY, onlay	Rarely RAMIREZ	Rarely RAMIREZ, tar
General hospital 4	ONLAY, sublay, ipom	SUBLAY, onlay, ipom	Rarely RAMIREZ	TAR, Ramirez
General hospital 5	SUBLAY**, onlay	SUBLAY	SUBLAY+BRIDGING	TAR
General hospital 6	ONLAY	SUBLAY, onlay	SUBLAY+BRIDGING	TAR
General hospital 7	SUBLAY**	SUBLAY, ipom	Did not perform	TAR
General hospital 8	ONLAY, ipom	SUBLAY, onlay, ipom	Did not perform	Do not perform
General hospital 9	ONLAY, sublay	SUBLAY, onlay	X	X

Figure 1. Location of general hospitals where TAR workshops were held between 2015 and 2020 (red dot = medical center; blue dots = general hospitals).

	2015	2016	2017	2018	2019	2020
Medical center					TAR	TAR
General hospital 1	TAR					
General hospital 3		TAR				
General hospital 4			TAR			
General hospital 5				TAR		
General hospital 6					TAR	TAR
General hospital 7						TAR

Table 2. Introduction of TAR (and the number of operations) during workshops in Slovenian hospitals since 2015

Figure 2. TAR book (freely downloadable at www.hernia.si/UserFiles/File/combinepdf.pdf).

Figure 3. Patient before and after TAR (courtesy of Tomaž Jakomin, Izola General Hospital).

Figure 4. Patient before and after TAR on the right side (hernia after complications post appendectomy).

Figure 5. Patient before and after TAR (operation combined with abdominoplasty; courtesy of Katarina Benković Golob, Novo Mesto General Hospital).

Discussion

The predominant surgical technique used in Slovenia for management of incisional hernia depends very much on the hospital and its own history and experience, but it was mostly performed with epifascially (onlay) positioned mesh for many years at most of the hospitals (11). Onlay mesh repair was long considered an easy-to-perform and reliable method to reinforce the abdominal wall after the defect had been closed, and it was widely used at two clinical centers and nine general hospitals as a method of choice until 2012 (11). Some colleagues from Jesenice General Hospital introduced a sublay mesh for incisional hernia into their daily practice as early as 1999 (7). An additional two hospitals were performing sublay before 2004 on a regular basis. IPOM was performed at two medical centers and three general hospitals before 2012, as mentioned in Table 1 (12, 13). In the case of large hernia defects, where the hernia edges could not be approximated, many hospitals performed sublay with bridging. Anterior component separation (Ramirez) has regularly been performed at Slovenj Gradec General Hospital since 2008 (14). In 2012, sublay hernia repair was promoted by the Slovenian Hernia Society in a symposium and workshop with Andrew Kingsnorth at the Ljubljana Medical Center (9). Since 2012, all general hospitals have started implementing sublay mesh repair into their daily repertoire by themselves, and mentoring has rarely been needed (11). Once sublay became a routine operation at many of the regional hospitals, introducing TAR was a logical continuation for very large incisional hernias.

Performing reliable incisional hernia repair remains an issue for all surgical departments and hospitals where laparotomies are performed. The majority of incisional hernias are not very large (transverse diameter < 8 cm) and can be repaired with a standard sublay mesh repair (Rives–Stoppa). Its uncomplicated surgical technique and good long-term recurrence rate make this operation a great tools in the hands of a hernia surgeon. It seems to be ideal if incisional hernias can be repaired adequately within the hospital of their origin (e.g., primary operation), but this might not always be the best solution for very large hernia defects and comorbid patients, for whom a multidisciplinary approach is needed (15). When the transverse diameter of the hernia opening (neck) is wider than 8 to 10 cm, component separation is usually needed (16). This is especially common in very thin patients and hernia location above the umbilicus (e.g., in the subxyphoidal region) (17). To avoid compromises (such as bridging), in which mesh is exposed to subcutaneous tissue, various release techniques can be performed, TAR being one of the best in combination with sublay repair.

In the same way, as onlay/sublay paradigm changes occurred in 2012, the TAR technique was introduced at the Golnik Clinic by Rene Fortelny from Vienna during the sixth Slovenian hernia symposium with international participation (10). In the years that followed, nine hands-on workshops were held at various Slovenian general hospitals and at one medical center. However, teaching and learning TAR is not the same as teaching other less complicated hernia operations because TAR is a complex procedure with many pitfalls (18–20). Accordingly, an interdisciplinary approach by many specialists is needed (20). Surgical expertise is needed, and mentoring individual steps of the operation was possible after experience with over 50 TARs of the mentoring surgeon. All safety tips should be considered; among these are careful and complete dissection, division of medial perforators, and identification and preservation of neurovascular bundles (18). In our opinion, BTA administration is important in large transverse defects over 15 cm to avoid bridging or to make possible only unilateral TAR (21). There are increasingly more reports that BTA application might help even with smaller diameters for performing one-sided TAR and reducing tissue trauma. In the case of morbid obesity, prior bariatric surgery was advised (22). Accordingly, one of our patients received a laparoscopic gastric sleeve to lose 20 kg of weight prior to hernia surgery. All patients received perioperative pain control by epidural catheter and surveillance in intensive care unit for 24 to 72 hours postoperatively because postoperative hematomas, respiratory distress due to elevated intraabdominal pressure, and other complications are not uncommon (19). No patient had developed recurrence 1 year after operation. Despite good initial results in all 10 patients in whom TAR was performed, we advise that great attention and concern be paid to the safety of the patients after a hospital decides to introduce this technique into its repertoire.

The recommendation of the Slovenian Hernia Society is in line with recommendations of the European Hernia Society. TAR is a demanding procedure with a very high risk of complications, and

our recommendation is that not all general hospitals in Slovenia should perform TAR. This should be limited to a maximum of two or three general hospitals, in addition to two medical centers. The criteria for inclusion should be a high number of experienced (hernia) surgeons, a sufficient volume of large incisional hernias (at least 10 per year), a sufficient number of other specialists available due to the interdisciplinary approach needed, BTA application possibility, a surgical intensive care unit, and active postoperative follow-up of the patients. Regarding learning TAR: if surgery really is mostly about doing, then the teaching models we use may need to change to reflect this (23). According to the results above, we believe that personal education with hands-on hernia courses is a strong tool for learning an operation. After the nine workshops that were carried out and mentioned above, three hospitals, in addition to both clinical centers, fulfill the criteria and could start performing TAR on their own in the future after additional experience and passing the learning curve. Other hospitals with a lower hernia caseload could send their patients with very large hernias to centers where all the needed criteria are fulfilled. Even though it is true that TAR courses are a good tool for learning the technique, nothing can beat the individual interest and personal motivation of a local surgeon for learning a new operation and following his or her own results. It is thus encouraging that two Slovenian general hospitals joined the Herniamed registry in 2020 to improve the follow-up in their hernia surgery and learn from their own results.

Conclusions

Although TAR is a logical upgrade of the sublay procedure for large incisional hernias, it is not just "another hernia operation" and, despite the desire to fix "their own hernias," surgeons should be aware that TAR is not a procedure that can be performed at any hospital, nor can it be taught instantly. Due to the high possibility of postoperative complications, patients that need TAR should be operated on by experienced surgeons and at hospitals with sufficient expertise and interdisciplinary facilities.

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Ventral Hernia Repair Overview: What is the Current Situation in Slovenia?

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Key words

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Abstract

Background. Ventral hernias are common surgical conditions. Approximately 1,900 patients are treated for the condition in Slovenia every year. Different classification systems and repair techniques exist, and different surgical approaches are currently possible. Often there is a misinterpretation of nomenclature due to different terms often being used interchangeably. The multiple nomenclature arises from two different authors: Rives and Stoppa. However, there is no doubt that the use of mesh is mandatory. Nevertheless, there is still debate about the optimal plane of mesh positioning.

Methods. A detailed literature review on ventral hernia classification and repair was performed. Retrograde analysis of data from the Health Insurance Institute of Slovenia was performed and combined with analysis of data from three medical institutions (Jesenice General Hospital, Slovenj Gradec General Hospital, and Izola General Hospital).

Results. Seventeen medical institutions performed ventral hernia repair in Slovenia. The ratio of primary versus incisional abdominal wall hernia repair was constant, ranging from 31.9 to 33.4%. The single most coded procedure in primary abdominal wall hernias according to the Slovenian classification of therapeutic and diagnostic procedures was epigastric hernia repair (50–61.9%), whereas in incisional abdominal wall hernias the most often coded procedure was hernia repair with mesh (69.2–73.7%). There was a high percentage of incisional hernia repair without mesh (21.6–29%).

Conclusion. Data collection in Slovenia is difficult. The hernia registry is the only tool that allows efficient data collection and analyses. Today, in ventral hernia repair, mesh use in the sublay position is the preferred method.

Introduction

Incisional and primary abdominal hernias are common. Worldwide as many as 2,000,000 patients are operated on every year (1). Based on the Health Insurance Institute of Slovenia (HIIS) data in the period from January 1st, 2015 to December 31st, 2017, up to 1,900 patients were treated for different types of ventral hernias yearly. Once considered a relatively simple problem by many physicians and patients, abdominal wall hernias are now known to be more complex. Different surgical techniques are currently available, based on the mesh positioning in the abdominal wall: onlay, inlay, sublay, and IPOM/underlay (2). The surgical approach may be open, laparoscopic, endoscopic within the abdominal wall, or a hybrid, which combines the methods mentioned above (1). Although the added dissection establishes a retromuscular space, many studies show that sublay mesh placement has the lowest incidence of ventral hernia recurrence. According to some studies, the incidence of ventral hernia recurrence is less than 5% (1, 3–5).

This article reviews the literature on abdominal wall hernia repair and highlights the Slovenian ventral hernia repair situation.

Methods

We performed a retrograde analysis of data from patients registered by the HIIS from January 1, 2015 to December 31, 2017. The HISS maintains the registry used at 17 Slovenian medical institutions. Additional information about ventral hernia repair was gathered from three additional medical institutions (Izola General Hospital, Jesenice General Hospital, and Slovenj Gradec General Hospital).

According to the Slovenian classification of therapeutic and diagnostic procedures (TDP), 12 different codes were assigned for different ventral hernia repair procedures. With the help of the TDP seven-digit code, we calculated the number of ventral hernia repair procedures for each of the 17 medical institutions in Slovenia. For better insight, we analyzed the data for 3 consecutive years.

Nomenclature

Based on the mesh positioning in the abdominal wall, the sublay repair technique means that the mesh is placed between the anterior side of the peritoneum and the posterior side of rectus abdominis muscle (6). However, misperception of the nomenclature is due to many terms used (often interchangeably) to describe mesh placement in this plane, such as *retromuscular*, *retrorectus*, *preperitoneal*, and *Rives–Stoppa*. A large portion of this confusion arises from the initial description of the technique by Jean Rives and Rene Stoppa in France in the 1960s (7). Stoppa and Rives used different terminology because of the anatomical differences in their respective operative fields. Whereas Stoppa's operative field took place inferior to the arcuate line, where the posterior sheath of the rectus abdominis muscle does not exist, Rives' operative field was superior to the arcuate line, where the posterior sheath of the rectus abdominis muscle is intact (8). Thus, inferior to the arcuate line, the mesh is placed in the preperitoneal space but, superior to the arcuate line, the mesh is placed not only in the preperitoneal space but also anterior to the posterior rectus sheath, better known as retromuscular placement (7, 8).

In summary, the sublay or Rives–Stoppa repair can have different synonyms (6–8): superior to the arcuate line (Rives) *prefascial*, *retromuscular*, or *retrorectus*, and inferior to the arcuate line (Stoppa) *preperitoneal* or *retrofascial* (8, 9).

Classification of Ventral Hernias

The latest ventral hernia classification was created by the European Hernia Society group in 2009. The group divided ventral hernias into primary abdominal wall hernias and incisional abdominal wall hernias. Parastomal hernias were excluded from this classification due to specific properties and treatment options (10).

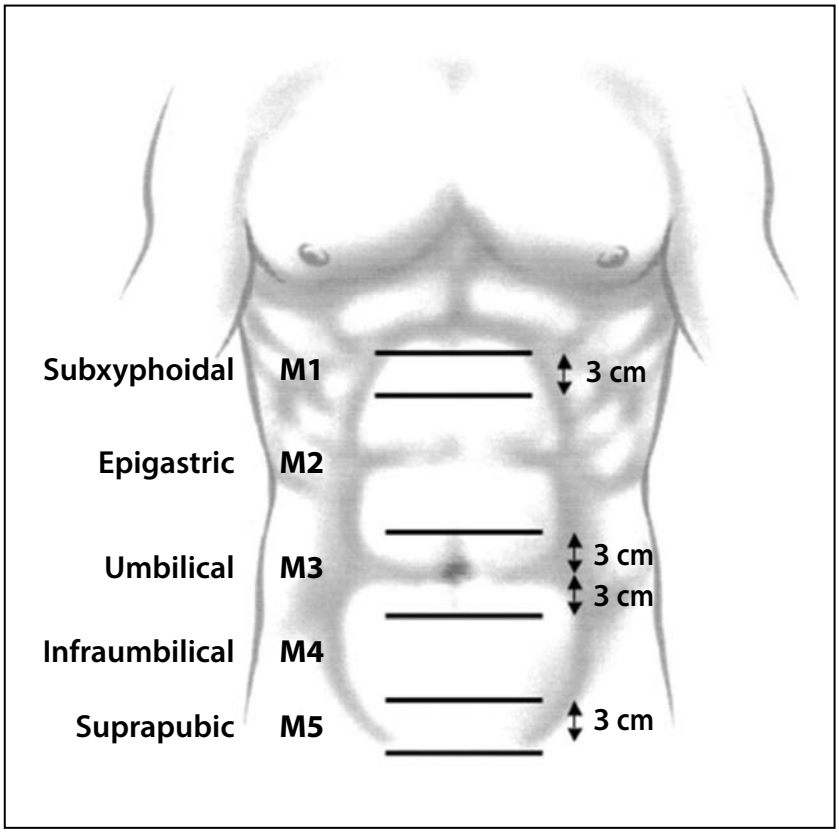
For primary abdominal wall hernias, localization and size were defined as the two variables to use. Both of them are shown in Table 1.

An incisional abdominal wall hernia was defined as "any abdominal wall gap with or without a

Table 1. European Hernia Society (EHS) classification for primary abdominal wall hernias.

EHS primary abdominal wall hernia classification		Diameter		
		Small < 2 cm	Medium 2–4 cm	Large ≥ 4 cm
Midline	Epigastric			
	Umbilical			
Lateral	Spigelian			
	Lumbar			

Figure 1. European Hernia Society (EHS) classification of midline incisional abdominal wall hernias.



bulge in the area of a postoperative scar perceptible or palpable by clinical examination or imaging" (11). As in primary abdominal wall hernias, localization and size were defined as the two essential variables to use.

To address the localization of the hernia, the abdomen was divided into a medial or midline zone and a lateral zone. The borders of the midline area are shown in Figure 1 and were defined cranially as the xyphoid, caudally as the pubic bone, and laterally as the lateral margin of the rectal sheath. Between the two lateral rectal muscle sheaths, five different zones were defined (M1: subxyphoidal, M2: epigastric, M3: umbilical, M4: infraumbilical, and M5: suprapubic).

The borders of lateral area are shown in Figure 2, and were defined cranially as the costal margin, caudally the inguinal region, medially the lateral rectal muscle sheath margin, and laterally the lumbar region. Four zones are then defined on each side (L1: subcostal, L2: flank, L3: iliac, and L4: lumbar).

In contrast to primary abdominal wall hernias, incisional hernias come in many different sizes and shapes. Because of this, it was agreed that

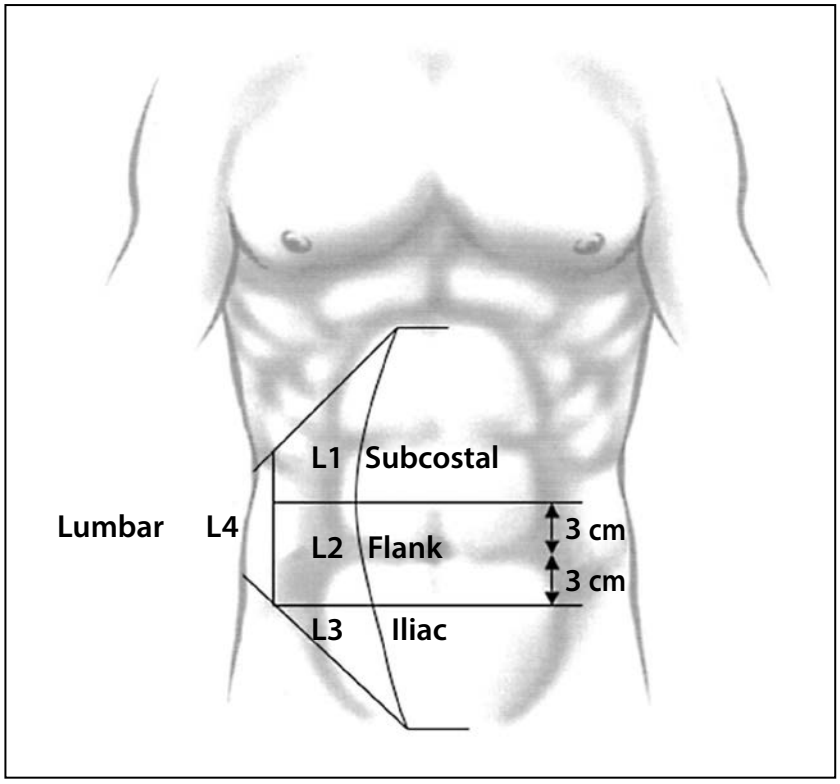


Figure 2. European Hernia Society (EHS) classification of lateral incisional abdominal wall hernias.

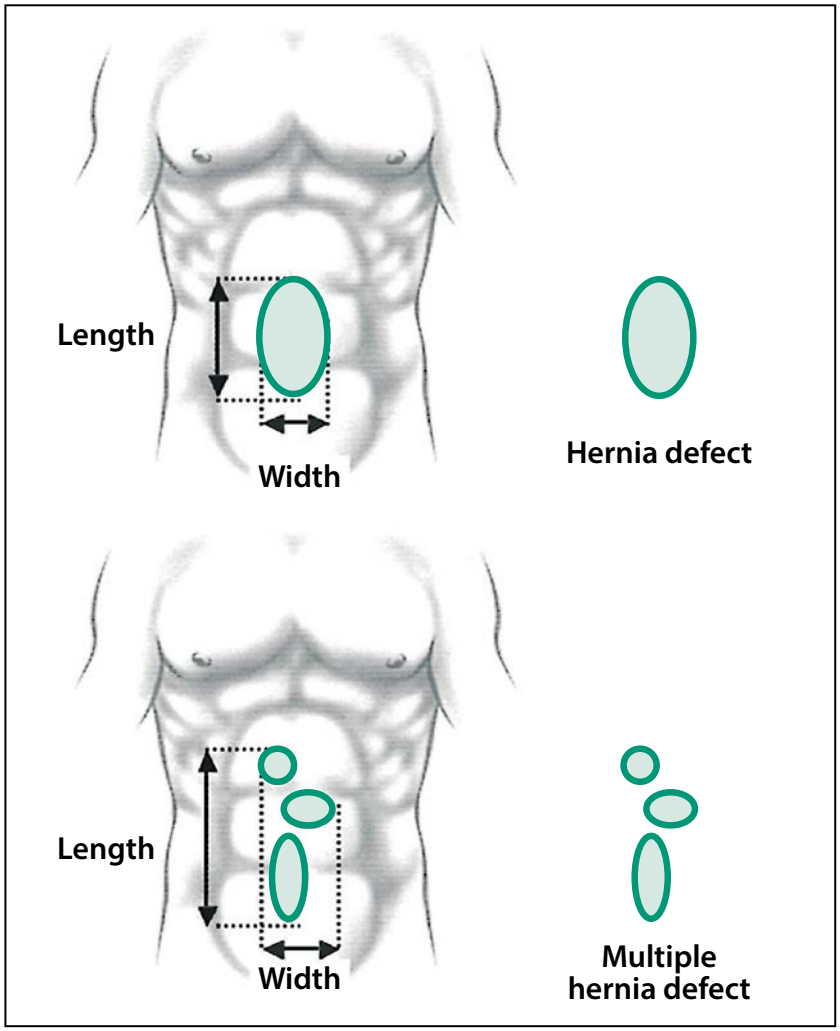


Figure 3. European Hernia Society (EHS) definition of the width and the length of incisional hernias for single hernia defects and multiple hernia defects.

width and length should be used to assess hernia size. The hernia defect's width was defined as the greatest horizontal distance in centimeters between the lateral margins of the hernia defect on both sides. To avoid confusion with primary abdominal wall hernias (small, medium, and large), a coded taxonomy was chosen (W1 < 4 cm, W2 4–10 cm, and W3 ≥ 10 cm) instead of a nominative one. In the case of multiple hernia defects, the width and length are measured between the most distally located margins of the most distal defect, as shown in Figure 3.

There are also other important currently existing classifications of ventral hernias, all of them using hernia defect size, localization of the hernia, and number of previous repairs as variables (11–13).

Ventral Hernias in Slovenia

The data about the ventral hernia situation in Slovenia were gathered from the HIIS. Data for 3 consecutive years were analyzed, from 2015 to 2017.

According to the sixth edition of the Slovenian classification of TDP, 12 seven-digit codes describe different ventral hernias (14). For this review, data were analyzed for the following 10 different codes.

Primary abdominal wall hernias:

- Hernioplasty without mesh (3040301)
- Hernioplasty with muscle transposition (3040503)
- Hernioplasty with mesh (3040504)
- Hernioplasty with bowel resection due to incarceration (3040505)
- Hernioplasty of epigastric hernia (3061701)
- Hernioplasty of linea alba hernia (3061702).

Incisional abdominal wall hernias:

- Hernioplasty without mesh (3040300)
- Hernioplasty with muscle transposition (3040500)
- Hernioplasty with mesh (3040501)
- Hernioplasty with bowel resection due to incarceration (3040502).

Umbilical hernias were excluded because they will be covered separately.

Results

Data for all 17 medical institutions that perform ventral hernia repair are shown in the following tables (Tables 2–4).

In Slovenia, 17 medical institutions perform ventral hernia repair surgery. Thirteen of them are public hospitals (two of these are tertiary medical centers) and four are private care medical centers.

An average number of 877.7 ventral hernia repairs a year were performed from 2015 to 2017, with the number gradually increasing. The ratio of primary versus incisional abdominal wall hernias among all repairs was constant, ranging from 31.9 to 33.4%.

Primary Abdominal Wall Hernias

The total number of primary abdominal wall hernia repairs ranged between 254 and 313 cases per year. The single most coded procedure was epigastric hernia repair (50–61.9%), followed by linea alba repair and hernia repair without mesh.

Incisional Abdominal Wall Hernias

Two-thirds of all abdominal wall hernia repairs were due to previous abdominal surgical procedures. Hernia repair with mesh was the most often performed procedure (69.2–73.7%). There was a high percentage of incisional hernia repair without mesh (21.6–29%).

Data on the type of hernioplasty in incisional abdominal wall hernia were gathered separately from three hospitals: Jesenice General Hospital, Slovenj Gradec General Hospital, and Izola General Hospital. In the first two institutions, in all of the patients a Rives–Stoppa / sublay technique was performed, whereas at Izola General Hospital 29% of patients had an onlay repair.

Discussion

Primary and incisional abdominal wall hernias have many similarities. They are both abdominal wall defects, predominantly located in the linea alba, and they share similar symptoms such

Table 2. Ventral hernia repairs performed by institution in 2015. Epig. = epigastric hernia.

Institution	Primary and incisional abdominal wall hernias								Epig.	Linea alba
	3040300	3040301	3040500	3040501	3040502	3040503	3040504	3040505	361701	3061702
Medical Center 1										
Medical Center 2				98						
Medical Center 3										
Medical Center 4	26			34					1	
Medical Center 5	6			2					34	3
Medical Center 6	8	1		14			1	2	1	9
Medical Center 7	23		1	28			2		11	8
Medical Center 8	21	2		4					8	2
Medical Center 9				33			2		11	2
Medical Center 10	3		2	37					6	1
Medical Center 11	9			21			3		10	6
Medical Center 12	1	17		3			7		5	1
Medical Center 13	6			30		1	1	1	8	3
Medical Center 14	16	1		44					26	1
Medical Center 15	15			13			3		9	1
Medical Center 16										
University Medical Center 1	25	3	4	60			10		11	1
University Medical Center 2	27	1	1	23			2		13	2
Total	**186**	**25**	**8**	**444**	**3**	**1**	**31**	**3**	**154**	**40**

as discomfort, pain, and potential incarceration. However, despite these similarities, the etiology of both types of hernias is thought to be different. Primary hernias can be considered a congenital condition, whereas incisional hernias represent a iatrogenic technical or wound-healing problem (15). Several studies have demonstrated a significant difference between hernia characteristics, symptoms, the type of repair, and the outcomes for primary abdominal wall hernias and incisional hernias. Hence, these hernia entities should not be pooled together (15–19).

Mesh reinforcement is recommended in hernia repair for defects larger than 2 cm (5), whereas in umbilical and small epigastric hernias mesh use is recommended even in defects larger than 1 cm (20). In our data group, the range of hernioplasty without mesh for primary abdominal wall hernia, coded 3040301, varied between 7.4 and 15%. Data gathered from HIIS about primary abdominal wall hernia offer no information about hernia size, patient selection, and type of procedure. The same is true about data regarding epigastric hernias and linea alba hernias. In the linea alba group, there are no data about the use of mesh reinforcement.

Incisional abdominal wall hernias are the most common type of abdominal wall hernias. Hernia repair with mesh is currently the gold standard of

Table 3. Ventral hernia repairs performed by institution in 2016. Epig. = epigastric hernia.

Institution	Primary and incisional abdominal wall hernias								Epig.	Linea alba
	3040300	3040301	3040500	3040501	3040502	3040503	3040504	3040505	361701	3061702
Medical Center 1									1	
Medical Center 2			1	119						
Medical Center 3										2
Medical Center 4	15			48			1		46	1
Medical Center 5	3								2	
Medical Center 6				12			8			5
Medical Center 7	19		2	33	1		4		23	6
Medical Center 8	14	1	1	10					6	3
Medical Center 9			1	24			1	1	17	1
Medical Center 10	6		1	38	1				14	
Medical Center 11	7	1	1	43		1	11	1	9	2
Medical Center 12	2	10		2			4	2	11	3
Medical Center 13	16	2		17			4		19	10
Medical Center 14	12			40			1		11	1
Medical Center 15	9	3		26			2		7	2
Medical Center 16										
University Medical Center 1	24	2	3	52			9		12	6
University Medical Center 2	9	4		13	2		2	1	16	1
Total	**136**	**23**	**10**	**477**	**4**	**1**	**47**	**5**	**194**	**43**

management. Mesh repair results in a lower recurrence rate and less abdominal pain, and it does not result in more complications than suture repair regardless of the size of the hernia (21, 22). In Slovenia, based on HIIS data, up to 29% of hernia repairs are still without mesh. Emergency operations such as incarceration with or without concomitant bowel resections are coded separately.

Data from HIIS offer no clue about the type of mesh repair in incisional abdominal wall hernias. Data from three medical institutions (Jesenice General Hospital, Slovenj Gradec General Hospital, and Izola General Hospital) were gathered separately about the type of mesh repair. The most used technique was the sublay / Rives–Stoppa repair. Currently comparing sublay versus onlay incisional hernia repair, fewer surgical site infections and recurrences were identified with the sublay technique (23). This was also confirmed by data from the Danish Hernia Registry (24). Nonetheless, an expert consensus guided by systematic review found that, although the sublay operation should be given preference for incisional hernia repair, the onlay mesh location might be useful in certain settings (5).

Table 4. Ventral hernia repairs performed by institution in 2017. Epig. = epigastric hernia.

Institution	Primary and incisional abdominal wall hernias								Epig.	Linea alba
	3040300	3040301	3040500	3040501	3040502	3040503	3040504	3040505	361701	3061702
Medical Center 1									1	
Medical Center 2				113						
Medical Center 3	13		2	73					1	2
Medical Center 4	10			1					42	
Medical Center 5										
Medical Center 6	2		4	10	1		3	2	1	5
Medical Center 7	19	1	1	24			5		8	7
Medical Center 8	9	2		10	1				1	
Medical Center 9	3	2		24					14	14
Medical Center 10	3			32	1		1		9	1
Medical Center 11	6		1	34		1	9	1	8	1
Medical Center 12	3	16		3		1	7	1	3	1
Medical Center 13	11	10		16			7		7	6
Medical Center 14	16	2		30					18	4
Medical Center 15	5	2	1	19			4		5	2
University Medical Center 1	20	6	3	60		1	9		23	2
University Medical Center 2	32	4	2	26			6		9	2
Total	**152**	**45**	**14**	**475**	**3**	**3**	**51**	**4**	**150**	**47**

Conclusions

In the absence of a Slovenian hernia registry, data analysis is complicated. Data collection from different institutions is difficult due to poor responsiveness. Data from HIIS are mainly meant for financial reimbursement and not for surgical analysis. The appropriate direction to go now is probably to rely on a foreign hernia register. So now, two institutions (Izola General Hospital and the Iatros Medical Center) have joined the Herniamed registry. When dealing with a patient with an abdominal wall hernia, two main factors are important. The first is to define whether it is a primary or incisional abdominal wall hernia, and the second is to choose the right hernia repair technique. Currently, the sublay / Rives–Stoppa repair seems to be the method of choice, although the onlay repair could be equivalent or even superior in certain circumstances.

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Transversus Abdominis Release in Incisional Hernias at a Certified Hernia Center

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Abstract

Introduction. Not every hernia repair suits all patients with incisional hernias. This is especially true for large defects more than 10 cm in diameter. Although component separation techniques make it possible to close large defects, a number of complications can emerge with extensive tissue preparation.

Methods. Thirty-five patients underwent surgery. In patients with a hernia neck transverse diameter of > 10 cm (n = 10), posterior component separation with preoperative botulinum toxin A application was performed. Five patients had a transverse hernia neck defect > 14 cm. On average, the defect of the hernia neck was 9.8 cm longitudinally and 7.6 cm transversally. Botulinum toxin A was administered in seven patients with large hernias.

Results. The average age of patients was 63 years (61% female). Sublay was performed in 80% of patients, 11% of patients had onlay repair, and 9% had intraperitoneal onlay mesh. Fifteen patients underwent component separation, either anteriorly (n = 2) or posteriorly (n = 13). Posterior component separation was always performed as one- (30%) or two-sided (70%) transversus abdominis release with or without botulinum toxin A administration. The midline was completely closed in all patients. There have been no recurrences during the postoperative period since 2018. Postoperative complications included two postoperative hematomas (5%), two seromas (5%), and one abscess (2%).

Conclusion. Our initial results in 35 patients with large incisional hernias show no early recurrence. The low incidence of other postoperative complications may be a result of a changed paradigm from onlay toward the sublay approach at a recently established hernia center. In large hernias and loss-of- domain hernias, component separation and botulinum toxin A administration make an essential contribute to completing the midline closure.

Introduction

A registered hernia center should offer patients many surgical choices and alternatives. After this was established in July 2018 at our hospital, we started to perform a variety of procedures in order to offer every patient the best individual solution for his or her hernia in the sense of a tailored approach.

The optimal surgical technique in incisional hernia repair, especially for large abdominal wall defects, remains an ongoing debate. Extensive tissue preparation during component separation techniques provides abundant space for large prosthetic meshes, but at the same time this increases the risk of perioperative complications such as postoperative hematoma, seroma, and infection (1). Meta-analyses show that sublay repair has a lower risk of recurrence, seroma, and surgical site infection compared to other open techniques (2).

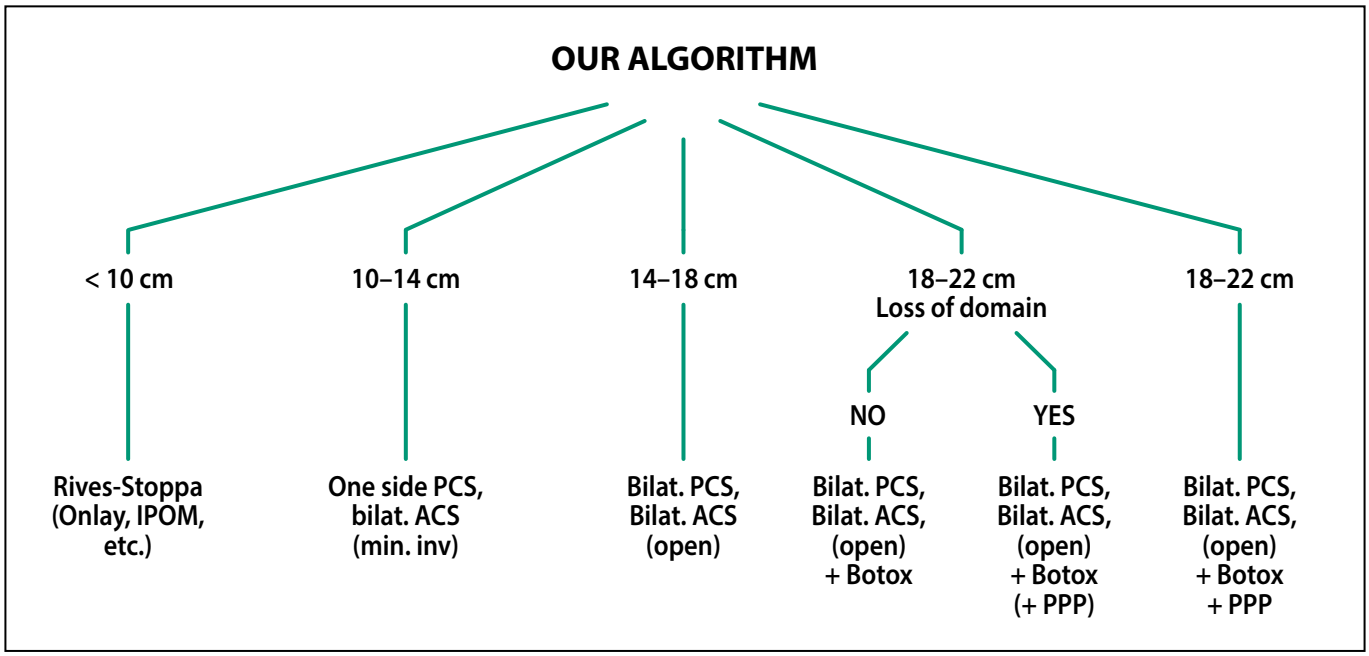
Methods

Thirty-five patients after incisional hernia repair were analyzed retrospectively by sex, age, operation technique, recurrence, and postoperative complications in the first 10 months at a certified hernia center (German Hernia Society, DHG) from July 2018 to April 2019. In patients with a hernia neck transverse diameter of > 10 cm (n = 10) one- or both-sided posterior component separation (PCS) with preoperative botulinum toxin A (BTA) application was performed. Five patients had a transverse hernia neck defect > 14 cm (loss of domain) and received the same treatment. The largest hernia defect measured 31 cm (longitudinally) × 17 cm (transversally). The average defect of the hernia neck was 9.8 cm longitudinally and 6 to 7 cm transversally. BTA was administered in seven patients with large hernias (diameter > 10 cm) 1 month preoperatively under sonographic guidance (300 I.U. 12 ml; 150 I.U. 6 ml each side, divided into three injection spots of 2 ml / 50 I.U. per injection spot on each side).

Results

The patients were 61% female and 39% male. The average age of patients was 63 years. The surgical technique was sublay in 80% of patients, based on Rives–Stoppa, regarding the position of the defect. Onlay repair was performed in 11% of patients and intraperitoneal onlay mesh (IPOM) in 9%. Minimally invasive procedures such as Milos (sublay) and EaLAR (onlay–augmentation) were

Figure 1. Algorithm for easier decision-making based on transverse hernia defect in patients with large incisional hernias (3).



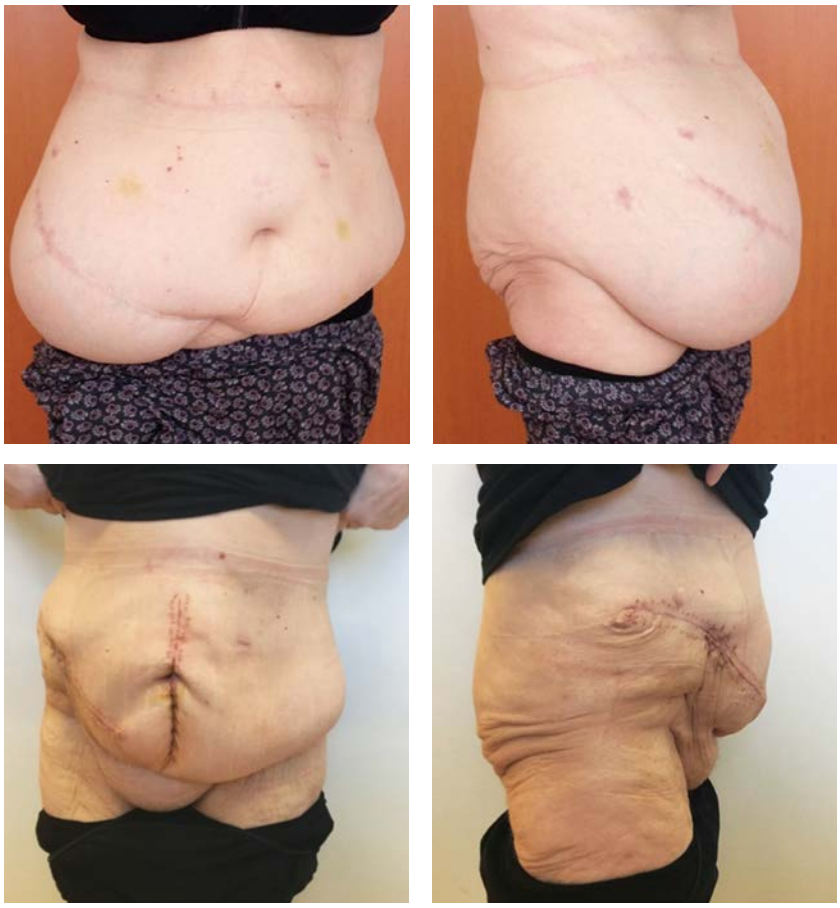


Figure 2. 62-year-old female patient before and after botulinum toxin A administration and transversus abdominis release on both sides due to loss of domain (defect 25 cm transversally after complications in right hemicolectomy).

Figure 3. 55-year-old female patient before and after botulinum toxin A administration and transversus abdominis release on the right side. The hernia size was 20 × 17 cm. The primary operation was on the iliac arteries (bypass)

also used in selected cases. Fifteen patients underwent component separation; either anteriorly (ACS, *n* = 2) or posteriorly (PCS, *n* = 13). In these patients, one- or both-sided PCS with or without preoperative BTA application was performed. No complications were observed immediately after BTA administration during preventive 24-hour observation post injection on the ward or later on. Reduction of hernia defect due to flaccid abdominal wall paralysis (checked by control CT scan) was not observed in all seven patients; however, the greatest reduction of defect after BTA administration was 3 cm in one patient. PCS was always performed as one- (30%) or two-sided (70%) transversus abdominis release. The midline was completely closed in all patients (without bridging). There have been no early recurrences in any of the 35 patients analyzed during the short postoperative period since 2018. Postoperative complications included two postoperative hematomas (5%), two seromas (5%), and one abscess (2%; treated with the vacuum sealing technique).

Discussion

A common sublay technique is not sufficient to cover the defect and especially to close the midline (linea alba) in patients with very large incisional hernias. In these patients, careful planning and individual decision-making is essential. Measuring the hernia neck and hernia volume in the CT scan is of utmost importance. If the transverse diameter of the defect is larger than 10 cm, some kind of component separation is needed (3). Some surgeons prefer BTA and then perform a conventional sublay in hernias if the transverse defect is > 10 cm (4). Our protocol starts with one-sided PCS and then, if needed, proceeds to both-sided PCS before BTA is administrated (in transverse hernias > 18 cm) (3, 4). If the hernia volume measured by CT exceeds 25% of the abdominal volume, one should be extremely careful because fascia closure is rarely possible in these patients without additional pneumoperitoneum (3, 5).

In our own series of patients, we always achieved overlap of mesh of 10 to 15 cm laterally and omitted the originally described transfacial sutures (6). The main purpose of all procedures for releasing the abdominal wall is primary closure of the linea alba and avoiding bridging of the defect by mesh only (7).

Conclusions

Our initial results in 35 patients with large incisional hernias show no early recurrence. Low incidence of other postoperative complications may be a result of the changed paradigm from the onlay to sublay approach at a recently established hernia center. In large and loss-of-domain hernias, component separation and BTA administration essentially contribute to completing the midline closure. Further follow-up (1, 5, and 10 years postoperatively) of all patients is mandatory and is planned in the Herniamed registry.

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Guidelines for Treatment of Umbilical and Epigastric Hernias

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Abstract

Background. Umbilical and epigastric hernia repairs are frequently performed surgical procedures with an expected low complication rate. Surgical repair—open or laparoscopic—is the only treatment for a hernia. This article presents guidelines for the treatment of umbilical and epigastric hernias.

Methods. The guideline group consisted of surgeons from Europe and North America, including members of the European Hernia Society and the Americas Hernia Society. A systematic literature search was performed on May 1st, 2018 and updated on February 1st, 2019. Recommendations regarding umbilical and epigastric hernias were gathered from Slovenian surgeons, the Iatros Clinic, the Ljubljana Medical Center, the Maribor Medical Center, Slovenj Gradec General Hospital, Izola General Hospital, and Celje General Hospital.

Results. The main recommendation was to use mesh for repair of umbilical and epigastric hernias to reduce the recurrence rate. Most umbilical and epigastric hernias may be repaired by an open approach with preperitoneal flat mesh. A laparoscopic approach may be considered if the hernia defect is large or if the patient has an increased risk of wound morbidity.

Conclusion. The only strong recommendation based on high-quality evidence was to use mesh for defects of at least 1 cm to reduce recurrence. For small umbilical and epigastric hernias (0–1 cm), either open mesh repair or a sutured repair can be used. For symptomatic, medium-sized hernias (from 1 to 4 cm), open repair with preperitoneal flat mesh is recommended. This technique is feasible and cheap, and it is indicated in high-income regions as well as in middle- and low-income regions. Laparoscopic repair is recommended for large defects (over 4 cm), in obese patients, or for multiple defects.

Introduction

An umbilical hernia is defined as a primary hernia with the defect located in the midline in the center of the umbilical ring. An epigastric hernia is defined as a hernia with the center of the defect in the midline above the umbilicus up to the xiphoid process. Based on the defect diameter, the guideline group classified umbilical and epigastric hernias into small (0–1 cm), medium (1–4 cm), and large (over 4 cm).

Umbilical hernias are common; asymptomatic hernias may be present in up to 25% of the population when examined by ultrasound imaging. The overall number of umbilical hernia repairs is higher in men than women. The age-specific prevalence was observed to peak in early childhood (0–5 years) for both sexes, in older age (61–70 years) for men, and in middle age for women (31–40 years). The number of repairs for epigastric hernias was similar for both sexes, with the age-specific prevalence peaking at 51 to 70 years for men and 41 to 50 years for women. Umbilical and epigastric hernias are typically diagnosed by clinical examination only. For asymptomatic umbilical and epigastric hernias, a watchful waiting strategy can be suggested. Wound complications are most common in ventral hernia repair. It is suggested that patients stop smoking for 4 to 6 weeks and reduce BMI below 35 kg/m^2 before elective umbilical or epigastric hernia repair. Prophylactic antibiotics, given as a single preoperative dose, are suggested when mesh is used for umbilical or epigastric hernia repair. It is recommended that mesh be used for the repair of umbilical and epigastric hernias to reduce the recurrence rate. A sutured repair can be considered in shared decision-making and for small hernia defects of less than 1 cm. Umbilical and epigastric hernias can be repaired safely using synthetic polypropylene mesh. Flat permanent mesh is preferably placed in the preperitoneal space for open umbilical or epigastric hernia repair. An overlap of 3 cm is suggested for defects of 1 to 4 cm. A non-absorbable suture is used for mesh fixation. The surgeon and anesthetist agree on the type of anesthesia: local or general.

Table 1. Umbilical and epigastric hernia repairs in 2018 in Slovenia.

Hospital			
	3040300	3040301	
Medical Center 1			
Medical Center 2			
Medical Center 3			
Medical Center 4	13		
Medical Center 5	10		
Medical Center 6	2		
Medical Center 7	19	1	
Medical Center 8	9	2	
Medical Center 9	3	2	
Medical Center 10	3		
Medical Center 11	6		
Medical Center 12	3	16	
Medical Center 13	11	10	
Medical Center 14	16	2	
Medical Center 15	5	2	
University Medical Center 1	20	6	
University Medical Center 2	32	4	
Total	152	45	

Laparoscopic Repairs of Umbilical and Epigastric Hernias

Laparoscopic repair is considered for large (over 4 cm) umbilical or epigastric hernias or if the patient has an increased risk of wound infection.

It is suggested that the defect be closed when possible, and that mesh be placed in the preperitoneal or retromuscular position with an overlap of at least 5 cm. It is suggested that intraperitoneal mesh be fixed with non-absorbable sutures or tacks.

The most common complication after umbilical and epigastric hernia repair is wound morbidity. Obesity, smoking, diabetes, and immunosuppression are factors known to be associated with wound complications. The learning curves for open and laparoscopic umbilical and epigastric hernia repair is suggested to be around 20 and 30 supervised procedures, respectively.

In Slovenia, we performed an average of 1,850 umbilical and epigastric hernia operations annually from 2015 to 2018 (Table 1).

Most of them were repaired with open surgery, and only a few were operated laparoscopically. Laparoscopic repair is recommended for large defects (over 4 cm), in obese patients, or for multiple defects. Hospitals chose open repair more often, mostly because of the higher cost of laparoscopic surgery compared to standard open surgery (cost-benefit) but also due to time restraints, with laparoscopic surgery usually taking more time. Surgeons based their decisions on choosing open or laparoscopic repair on their knowledge and experience, and the capabilities of the hospital. Based on the preference of the surgeon and hospital, different meshes are used in Slovenia: Parietex™ Composite Ventral Patch, Proceed Ventral Patch (PVP), Parietene™ Macro PP, and Trulene Lapro Mesh. A sutured repair can be considered in shared decision making and for small hernia defects of less than 1.5 to 2 cm. A non-absorbable suture is used for mesh fixation. Most of

Umbilical and epigastric						Incarc.	Umbilic.	Epig.	Linea alba	All
3040500	3040501	3040502	3040503	3040504	3040505	3061500	3061700	3061701	3061702	
							11	1		12
	113									113
							9	1	2	12
2	73						94	42		224
	1									11
4	10	1		3	2	11	16	1	5	55
1	24			5		16	101	8	7	182
	10	1				4	17	1		44
	24						50	14	14	107
	32	1		1		4	47	9	1	98
1	34		1	9	1	5	51	8	1	117
	3		1	7	1	14	40	3	1	89
	16			7		19	75	7	6	151
	30					8	59	18	4	137
1	19			4		1	21	5	2	60
3	60		1	9		18	88	23	2	230
2	26			6		16	58	9	2	155
14	475	3	3	51	4	116	737	150	47	1,797

the surgeons used the Mayo suturing technique with non-absorbable sutures. Prophylactic antibiotics are given as a single preoperative dose of Cefamezin 2 g when mesh is used for umbilical or epigastric hernia repair. Some surgeons continue with antibiotics for 2 to 3 days.

Discussion

This is the first European and American guideline on the treatment of umbilical and epigastric hernias. It is recommended that symptomatic umbilical and epigastric hernias be repaired by an open approach with preperitoneal flat mesh. Umbilical and epigastric hernia repairs are frequently performed surgical procedures with an expected low complication rate of 3.5%. The optimal repair method with the best short-term and long-term outcomes remains debatable. The choices are many. For instance, is it necessary to use mesh and, in the case of mesh repair, is a preformed patch better than flat mesh? Which anatomical layer should it be placed in? Furthermore, when is a laparoscopic approach preferable to an open approach? In recent decades, the European Hernia Society has facilitated the creation of several guidelines on the treatment and prevention of hernias, aiming at improving and standardizing hernia care. The Society of American Gastrointestinal Endoscopic Surgeons published a guideline on laparoscopic ventral hernia repair in 2016. An expert-guided consensus for the management of all types of ventral hernias exists. This is the first guideline that has been published on the treatment of umbilical and epigastric hernias specifically addressing both open and laparoscopic techniques.

The aim was to develop guidelines for the treatment of umbilical and epigastric hernias using watchful waiting or any surgical technique. The guideline group included surgeons from Europe and North America, thus including members from both the European Hernia Society and the Americas Hernia Society.

Conclusion

The only strong recommendation based on the high quality of evidence was to use mesh for defects of at least 1 cm to reduce recurrence. For small umbilical and epigastric hernias (0–1 cm), either open mesh repair or a sutured repair can be used. For symptomatic medium-sized hernias (1–4 cm), open repair with preperitoneal flat mesh is recommended. This technique is feasible and cheap, and it is indicated in high-income regions as well as in middle- and low-income regions. Laparoscopic repair is recommended for large defects (over 4 cm), in obese patients, or for multiple defects.

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Indications for Intraperitoneal Onlay Mesh Technique in Incisional Hernias

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Key words

incisional hernia, IPOM, laparoscopic repair

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Abstract

Background. Incisional hernia remains a very common postoperative complication. The use of mesh for abdominal wall reconstruction has significantly reduced hernia recurrence compared to primary repair. This article presents our experience with the laparoscopic intraperitoneal onlay mesh technique and sheds light on the indications, advantages, and disadvantages of the technique.

Methods. We analyzed all 27 patients that underwent incisional hernia repair in a 4-month period. Laparoscopic incisional hernia repair was performed on seven (24%) patients and an open approach on 20 (76%) patients.

Results. We compared two groups of patients in which laparoscopic and open repair was made. Laparoscopic surgery resulted in a longer operative time, minimal postoperative analgesic use, a shorter hospital stay, and no postoperative complications.

Conclusion. Laparoscopic intraperitoneal onlay mesh repair, where indicated, has several advantages. It is quick to perform and easy to replicate, and it maintains the integrity of the abdominal wall. Laparoscopic intraperitoneal onlay mesh repair involves trained surgeons, expensive equipment, and a long learning curve. The advantages are a short postoperative period and early return to work. In carefully chosen patients, laparoscopic intraperitoneal onlay mesh repair is a safe and effective alternative to other techniques.

Introduction

Incisional hernias remain a very common postoperative complication. These are encountered with an incidence of up to 20% following laparotomy (1). These hernias enlarge over time, making the repair difficult, and serious complications such as bowel obstruction, strangulation, and enterocutaneous fistula can occur. Hence, elective repair is indicated to avoid these complications. The recurrence rates after suture repair are as high as 58% (2). The use of mesh for abdominal wall reconstruction has

significantly reduced hernia recurrence compared to primary repair. The most common mesh repair techniques used are the onlay repair, sublay repair, and laparoscopic intraperitoneal onlay mesh (IPOM). There is much debate in ongoing and past trials about the advantages and disadvantages of each technique (3). This article presents our experience with laparoscopic IPOM technique, sheds light on indications for laparoscopic IPOM, and offers an overview of the advantages and disadvantages of the technique.

Methods

We analyzed all 27 patients that underwent incisional hernia repair in a 4-month period. Laparoscopic incisional hernia repair (LIHR) was performed on seven (24%) patients and an open approach on 20 (76%) patients. We compared the operative time, hospital stay, and complications between the two groups. We searched through the online PubMed database for recent publications regarding indications for laparoscopic IPOM as well comparative studies between laparoscopic IPOM and other techniques for incisional hernia repair.

Results

The average age in the laparoscopic group was 68 years and in the open group 67 years. The general condition of patients was assessed with the American Society of Anesthesiologist (ASA) score. Both groups had good general performance; ASA in the laparoscopic group was 1–2 and in the open surgery group 1–3. In the laparoscopic group, the average size of the defect was smaller (4.71 cm vs. 7.40 cm).

For LIHR, composite mesh was used in five patients and single-sheet mesh (expanded polytetrafluoroethylene, ePTFE) in two. The mesh was fixated transfascially with single sutures and tackers in three patients, and in the other four patients the mesh was fixated with double crown sutures. The operative time was longer in patients that underwent LIHR (180 min vs. 118 min), and the need for postoperative analgesics was minimal. Laparoscopic surgery shortened the hospital stay (3.0 days vs. 4.85 days). In the postoperative period there were no complications in the laparoscopic group; consequently, morbidity and mortality rates were 0%.

The follow-up period was 3 to 6 months, in which there were no cases of recurrence in this short time interval. Postoperative complications were present in two out of the 20 patients in the open group (10%): one patient had a wound infection and another patient a hematoma with no signs of hernia recurrence.

Discussion

Since the first description by LeBlanc and Booth (4), laparoscopic ventral hernia repair with IPOM is now an established surgical procedure for primary and incisional abdominal wall hernias. The intraperitoneal site of mesh placement with the possible sequelae (visceral adhesions, bowel obstruction, fistulization, and mesh migration) and bridging repair with prosthesis were concerns raised by some surgeons against the procedure. This led to the quest for an alternative site of mesh placement for hernia repair with a minimal access approach. The preperitoneal site for placement of mesh was described (transabdominal preperitoneal approach (TAPP) and transabdominal partially extraperitoneal approach (TAPE) for peripheral abdominal wall hernias) (5, 6). An endolaparoscopic retromuscular mesh repair for midline hernias was devised (RR approach, eTEP, and eRives–Stoppa). Lateral extensions of the retromuscular (retrorectus) plane were developed after division of the transversus abdominis muscle (TAR) for extraperitoneal placement of large meshes extending to paravertebral spaces (7).

These techniques have their advantages and disadvantages over IPOM. Endolaparoscopic retrorectus mesh repair for midline hernias is performed with minimal access but is surgically maximally invasive. It involves extensive mobilization of large myofascial flaps up to semilunar lines laterally to create the requisite retromuscular space for hernia repair and mesh placement. The surgical procedure requires division of the entire linea alba in the midline to create a large retrorectus space required for placement of mesh. A divided and sutured normal linea alba (with mesh reinforcement) is a poor substitute. In addition, there is

potential for damage to important neurovascular perforators laterally near semilunar lines.

During TAR, division of the transversus abdominis muscle has been reported to lead to hypotonia and bulging of the lateral abdominal wall. However, the potential deleterious effect of division and separation of the transversus abdominis muscle on the abdominal wall and respiratory function need to be observed and evaluated in the longer term. The use of multiple large sheets of mesh (30 × 30 cm) as reinforcement for the entire abdominal wall raises several concerns. The abdominal cavity is by its nature flexible and distensible, and large sheets of mesh encasing the abdominal wall including the flanks are expected to reduce mobility and therefore function. Mesh contamination and infection in such a scenario is expected to lead to great morbidity (8).

In the early days, laparoscopic adhesiolysis proved to be the most difficult and hazardous part of the surgical procedure. However, recent meta-analyses do not reveal any disadvantage of laparoscopic repair with regard to unrecognized enterotomies (9). The intraperitoneal location of foreign material was believed to be associated with adhesions leading to obstruction and enteric fistulization. Major cohort studies at the turn of the century could largely exclude these major sequelae. It was reported that intraperitoneal mesh placement is associated with a higher total adhesion score that may increase risk during subsequent laparoscopic surgery. Otherwise, adhesion-related complications have been described only anecdotally in terms of case reports. Major series based on well-controlled registry data do exist and rule out short- and medium-term complications after laparoscopic IPOM repair. The Danish Hernia Database shows that there is a relevant rate of revisional surgery after incisional hernia repair over time due to mesh-related complications for both open and laparoscopic approaches. After 5 years of follow-up, the cumulative incidence of mesh-related complications is 5.6% for open repairs and 3.7% for laparoscopic repairs. Current literature contains robust data ruling out any inferiority of laparoscopic hernia repair in terms of mesh-related complications caused by intraperitoneal placement (10).

The indications for laparoscopic IPOM repair are more clearly defined because the procedure has evolved over the decades. A low infection rate makes it suitable for use in patients at high risk of infection (diabetes, obesity, or immune compromised). It is indicated in patients with recurrent hernias after open repair, in patients with undisturbed abdominal wall function with Swiss cheese defects, small fascial defects with large primary incisions (to cover the entire scar), and lateral (L1–L3) hernia defects. It is not indicated for fascial defects larger than 8 to 10 cm (8).

Laparoscopic IPOM repair, where indicated, has several advantages. It is quick to perform and easy to replicate, and it maintains the integrity of the abdominal wall (8). Laparoscopic IPOM repair involves trained surgeons, expensive equipment, and a long learning curve. The advantages are a short postoperative period and early return to work. Although the hernia is repaired with mesh, the abdominal wall is not repaired and continues to be lax. The cosmetic effect of a pendulous and lax abdominal wall cannot be overemphasized. Some patients require other surgical procedures to improve abdominal cosmesis (3).

Conclusions

Incisional hernia is a common postoperative complication. Although hernia per se is benign, non-life-threatening condition, it has deleterious effect on patients' daily and social activities. Many different surgical interventions for hernia repair have emerged in recent years and are still evolving. Among these, laparoscopic IPOM in carefully chosen patients is a safe and effective alternative.

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Preoperative Application of Botulinum Toxin A in Operative Treatment of Ventral Hernia: Case Reports from Slovenj Gradec General Hospital

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Key words

botulinum toxin A, abdominal wall paralysis, Rives–Stoppa, ventral hernia

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Abstract

Background. Open procedures in the abdominal cavity still represent an important problem in abdominal surgery because we often still see incisional hernias after laparotomy. Many surgical techniques have evolved to optimize patient care and life quality to minimize the socioeconomic burden that postoperative hernias represent for society. The application of botulinum toxin A in the abdominal wall has been becoming increasingly popular among surgeons lately. It causes reversible flaccid paralysis of muscles, thereby helping close the abdominal wall.

Methods. At Slovenj Gradec General Hospital, 12 patients were treated with this method. The application turned out to be safe and effective. We operated on the patients mostly 4 to 6 weeks after the application, but in some cases up to 11 weeks and 5 days after, and used the Rives–Stoppa hernia repair technique.

Results. We observed a serious complication in one of the cases. A patient suffered serious bleeding, hemorrhagic shock, and later also perforation of the transverse colon. It was necessary to remove the mesh, and so the hernia was not resolved. Another patient experienced postoperative dehiscence of the wound, which was dressed with Rivanol dressing and healed without any complications. We observed a seroma, which resolved by itself in one patient. There were no recurrences of hernias at the time of publication of this article. All the patients are pleased with the results of the repair.

Conclusion. The preoperative application of botulinum toxin A in the abdominal wall in patients with ventral hernias is a relatively new method that is still being established globally and in Slovenia. The researchers proved that it is an effective, safe, and less invasive alternative compared to other repair techniques. Our experience with the procedure claims the same. To evaluate it and learn about long-term effects of the method described, and to determine which patients would benefit from it the most, will require more experience and information.

Introduction

Closure of the abdominal wall after open abdominal surgery remains a major challenge in abdominal surgery due to lateral retraction and tension of the abdominal wall musculature. Studies indicate postoperative hernias after primary surgery in 2 to 20% of cases (and even more based on certain data). An even higher percentage occurs in high-risk patients. Risk factors for the development of incisional hernias are diabetes, obesity, male sex, age, type of incision, immunosuppressive therapy, wound infection, and lung complications (1). The recurrence rate of ventral hernia after hernia repair is 30 to 70% (1–3). Each recurrence after a completed hernia repair causes deterioration in the abdominal wall and complicates further treatment (1, 3–5). The condition poses a great burden on the patient and is a socioeconomic problem for society. It constitutes a growing problem in the world.

There is a 31 to 56% chance of recurrence in primary suture closure of incisional hernias. The addition of a prosthetic mesh implant reduces the risk by 8 to 10%. Rives and Stoppa popularized the sublay technique in Europe, which has a low incidence of recurrence and minimal complication risk. The disadvantages of the method are its complexity, a lengthy operation, and the chance of chronic abdominal pain (6).

Closing the abdominal wall can cause severe postoperative pain, wound dehiscence, abdominal hypertension, ventilatory compromise, and elevated risk of hernia recurrence (3). The preoperative application of botulinum toxin A (BTA) causes flaccid paralysis of the lateral abdominal muscles and their relaxation. This results in lower wound tension when closing the abdominal wall (2). The method allows us to facilitate the apposition of the edges of the defect without disrupting the fascial integrity of the abdominal wall, as in component separation. This reduces the risk of infection, necrosis, dehiscence, and seroma. Seroma can lead to recurrence in more than half of cases, especially in the contaminated surgical field (4, 7).

When studying rats, it was proven that paralysis of the abdominal muscles reduces the number and size of incisional hernia. This confirms that abdominal wall muscle contractions play a significant role in the pathophysiology of incisional hernia formation. Treatment with BTA during laparotomy in the research described reduced the baseline tone and active forces in the abdominal muscles' activity and allowed the wound edges to rest closer to each other during recovery. This most likely helps the incision heal with less physical disturbance (8). They also proved that BTA not only helps with primary closure but also has a prolonged activity that protects the wound after the operation during the critical 3 months to heal better (9).

BTA inhibits acetylcholine release on the presynaptic nerve end and thus interrupts peripheral cholinergic transmission at the neuromuscular junction. The impulse transmission is gradually restored when the nerve fiber restores the connection with the postsynaptic neuromuscular junction (10, 11). With a low dose of BTA, the effect occurs after 2 to 3 days, and the greatest effect is achieved 5 to 6 days after injection. The complete effect lasts from 2 to 8 months (10). The clinical use of BTA is limited to the treatment of dystonia, spasticity, cerebral palsy, hyperhidrosis, hypersalivation, bladder dysfunction, and pain modulation. Its use with abdominal wall paralysis is not yet registered (7). Cases are also documented in which BTA was used to relieve postoperative pain after treating hernias, for intra-abdominal hypertension or compartment in critically ill patients, and for gastroschisis in newborns (7, 12).

The administration of BTA into the abdominal wall did not result in serious side effects or postoperative complications apart from light coughing and sneezing in the studies examined (4, 11). Some studies have reported superficial bruises after incisions. A bloating sensation has been documented as one side effect that started the 3rd day after the injections and was resolved after the hernia repair. Some patients reported back pain after the injection (9). The lateral abdominal muscles are also involved in accessory respiration. Therefore, there was an initial fear that BTA might affect the respiratory function after the operation (11). The treatment results in lesser thickness and increased length of the abdominal wall, defect reduction, and a reduced need for analgesics after the operation (1, 4, 11).

EMG or US can be used to identify the anatomical positions of the application (2). The EMG guidance complemented the US localization, confirming whether the muscle where we applied BTA was denervated or fibrotic, and it made it possible to modify the injection point to another muscular area, ensuring its effectiveness. Due to the poor technical standardization of the studies, little research, and

Figure 1. The anatomic location of the application from the upper left to the lower right: on both sides of the abdominal wall approximately along the anterior axillary line (orientation based on where we can see the anatomy of the abdominal wall) at three sites one above the other: subcostal, mid-abdomen, and above the iliac crest.

various methodologies, there are still several open questions about the use of BTA in hernia repair. Experts have established the need for improved standardization in future research of the effects of BTA on the abdominal wall (4).

Case series

Patients

From June 14th, 2019 to September 1st, 2021, 12 patients with a ventral hernia were operated on at Slovenj Gradec General Hospital. To prepare for the procedure, BTA was applied to their abdominal walls.

The patients were 46 to 78 years old, eight women and four men. All the patients suffered from ventral hernia, and three of them were simultaneously operated on for another pathology. Most of them were operated on for the first time due to this indication, one was operated on for the second time, and one for the third time; one of the patients had already had her fifth hernia repair that led to recurrence.

The causes of ventral hernias were various: condition after caecum perforation, condition after stomach perforation and revision, condition after laparoscopic cholecystectomy, and condition after sleeve gastrectomy and other bariatric procedures; in two cases, the cause of the hernia was intervention in the abdomen due to diverticulitis. Other reasons were rectal carcinoma, ascending colon operation, and sigmoid colon repair. We do not have the cause for one patient's hernia formation, but one of his previous operations led to bowel perforation, peritonitis, and sepsis, which is why the previously applied prosthetic mesh had to be removed.

The abdominal wall defect was mostly evaluated with a CT without contrast; in five patients, this was performed clinically. In six cases, a large portion of the abdomen's content "loss of domain" hernia was in the hernial sac.

Botulinum Toxin A Application

The patients were invited to the hospital approximately 4 to 6 weeks before the operation to apply Dysport®, 500 units. The application was US-guided. One ampoule of Dysport was diluted twice in 20 ml saline solution. The anatomical positions of application were as follows (Figure 1): on both sides of the abdominal wall approximately

along the anterior axillary line three sites, approximately one above the other, subcostal, mid-abdomen, and above the iliac crest. After disinfection of the skin in patients, 2 ml of the solution was applied to each of three muscle bellies (external abdominal oblique, internal abdominal oblique, and transverse abdominal) through a specific site under US guidance (Figures 2–5). Approximately 20 ml (3 × 3 × 2 ml) was injected into the side of the abdominal wall, and 40 ml of a 500-unit ampoule of Dysport diluted in saline solution into the entire abdominal wall. Patients were kept for observation for a few hours to 1 day, and then sent to home care. The application process did not show any major problems in patients. One of the patients noted a minor cough, two had a flabby stomach after the application, and one had a bruise. The patients did not have breathing problems or feel pain after the application. The application was carried out under US guidance by the same surgery specialist.

Operation

Patients were invited to come for the operation a few weeks after the application. The interval between the application and operation lasted a minimum of 4 weeks and 2 days, and a maximum of 11 weeks and 5 days. Patients were given 2 g of Cefamezin (cefazolin) preoperatively, an anti-ulcer and anti-thrombotic therapy, and a patient-controlled analgesia pump along with intravenous analgesics after the operation Almost all operations were carried out by the same surgeon (in two cases other surgeons were involved) using the Rives–Stoppa technique with a prosthetic mesh laid retromuscularly (sublay). During the operations we only observed problems with one patient: soon after the procedure, he became hemodynamically unstable; he required a revision due to hemorrhagic shock, and after a few days another one due to perforation of transverse colon. It was necessary to remove the mesh. The patient was kept in the hospital for 44 days and underwent an ileostomy. For the others hospitalization lasted 5 to 10 days (in most cases 5 days).

Follow-up

We are still tracing the patients' progress. No recurrence of hernias has been documented to date. The postoperative scars have healed and do not pose problems for any of them. Four of them have mild chronic pain on the lateral side of the abdomen, but the patients do not note any problems with bowel movement. Three of them have noted some flaccid tissue localized on their abdomen. One of the patients suffered from wound dehiscence measuring approximately 3 cm. A secondary suture was applied, and the wound was dressed with a Rivanol dressing. The wound then healed without complications. In one patient we found a seroma in wound that resolved by itself. All of the patients are pleased with the results of the procedure.

Discussion

Ventral incisional hernias remain a challenge for abdominal surgeons even with innovation in surgery. Primary closure of the defect in the abdominal wall is usually difficult due to lateral retraction and tension of the abdominal wall musculature. Botulinum toxin injections have proven to be a potentially good tool for reducing tension in the abdominal wall, shrinking hernias, and relieving the fascia reconstruction during closure of the abdominal wall (4).

Ibarra-Hurtado et al. were the first to publish a study in which BTA was applied to the abdominal wall before the operation. The application was done with the EMG control. The cross-sectional dimensions of the abdominal wall defect were measured weekly. The operation was carried out when the defect was no longer shrinking. In 3 to 4 weeks, the defect reduced by approximately 5.25 ± 2.32 cm. The hernia repair was carried out and, after an average follow-up of 9.08 months, no recurrence was documented (2). In 2014 a reduction of thickness and increase in length after injecting 250 units of BTA was noted in 17 patients with similar characteristics. The lengths were measured with a CT (9). Faroque et al. showed in their study that BTA induces thinning and extension of the lateral abdominal musculature, which is comparable with extending the musculature with surgical component separation (7, 9). Lien et al. published a study in 2015 in which they used three groups of rats to compare the size and frequency of incisional hernia occurrence based on the use of the BTA. The first group of rats did not have an incision, the second was injected with saline solution next to the incision, and the third with BTA. The wounds were incompletely closed. They proved that paralysis of the muscles reduces the number and size of

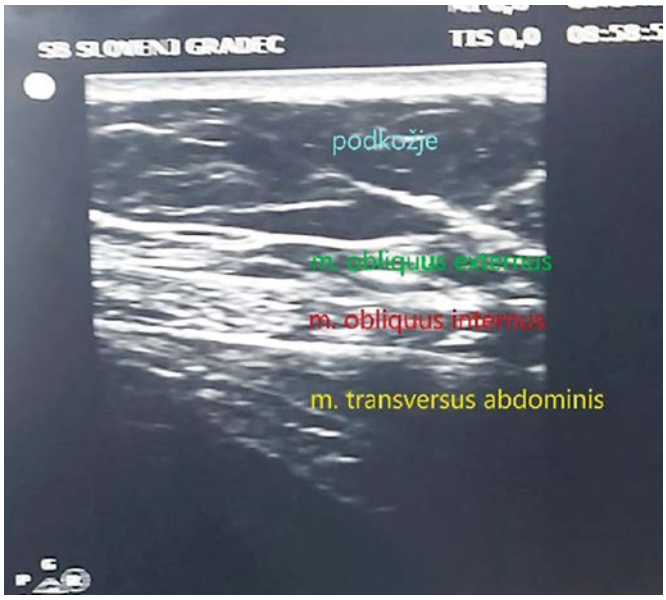

Figure 2. Ultrasound of muscle bellies at upper left.

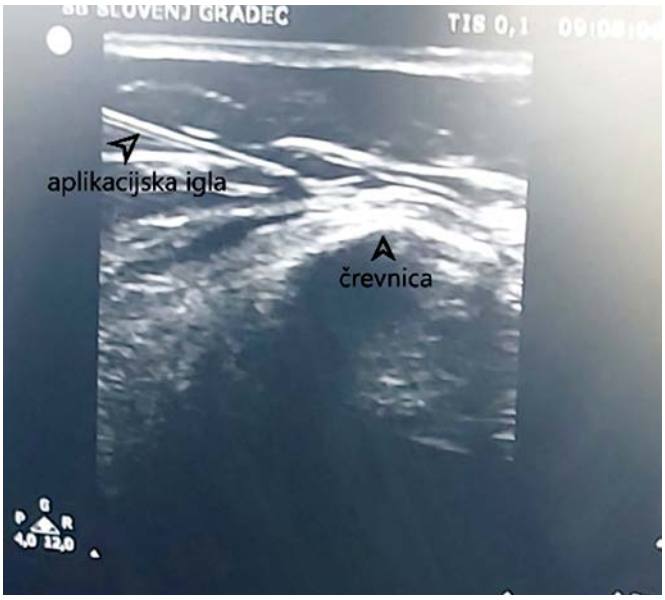

Figure 3. Ultrasound of muscle bellies at lower right. On the left is the needle for application of botulinum toxin A and on the right the iliac crest.

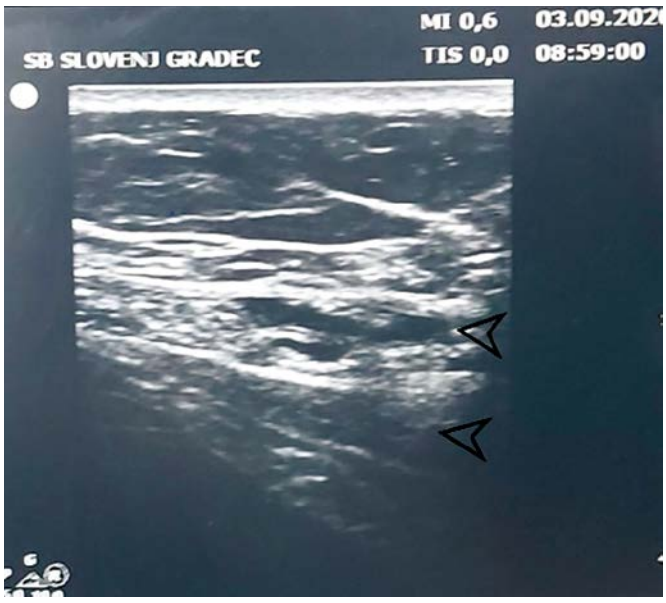

Figure 4. Solution injection into the transverse abdominal muscle and internal abdominal oblique muscle (arrows).

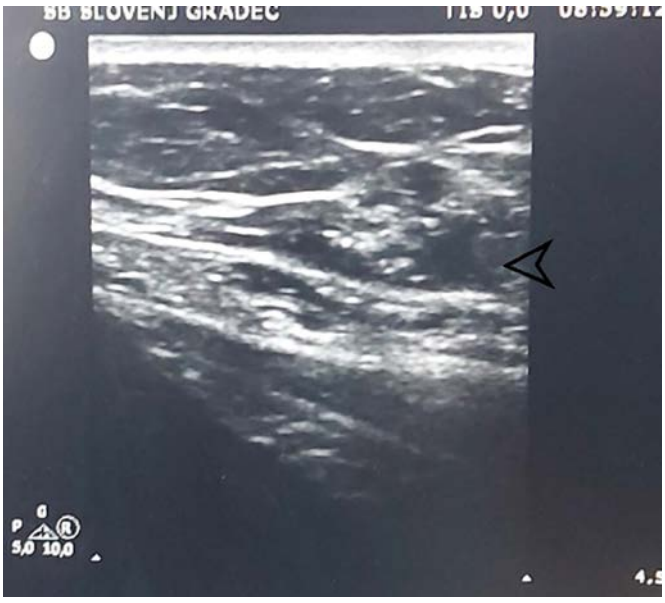

Figure 5. Solution injection into the external abdominal oblique muscle (arrow).

ventral hernias, and thus showed that abdominal wall muscle contractions play a significant role in incisional hernia formation (8).

In recent years, several meta-analyses were published that investigate the application of BTA to the abdominal wall in connection to treating incisional hernias. In 2017 based on 133 cases, Weissler et al. proved that the diameter of the hernia was reduced significantly after applying BTA; the lateral abdominal musculature, however, was extended (4). Jardim et al. analyzed 20 articles in 2009 and 2018. The statistical data showed that BTA injections reduce the thickness of the abdominal wall, extend its length, reduce preoperative pain and the hernia, and allow the wall repair with less tension. No complications were noted during the application.

BTA showed an important role in treating ventral hernias, not only because of the reduced diameter of the abdominal wall defect, but because of the abdominal wall muscle extension before the operation, which helps with defect closure. To date, several studies have confirmed this effect, and they also report the reduction of postoperative pain after the application. Due to the lack of technical standardization, a small number of studies, and varied methodology for intervention, the topic leaves many unanswered questions, such as: Which patients are most likely to benefit from this? Where are the optimal injection sites? What is the ideal volume and injection concentration? What is the best radiographic modality for abdominal wall analysis after injection? What is the safety profile of injecting BTA in the abdominal wall? Before BTA therapy becomes more widespread as a preoperative therapy, comparative cohort data on indication, application techniques, dosing, effectiveness, safety, and costs are required (11).

Conclusion

The use of BTA for preoperative preparation of the abdominal wall in ventral hernia reconstruction has proven to be a safe, effective, and less invasive alternative to other reconstruction techniques. The method was carried out in clinical practice at Slovenj Gradec General Hospital with encouraging results. For further evaluation of the procedure, a longer follow-up period and a higher number of systematically observed patients will be necessary.

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Follow-Up of Inguinal and Umbilical Hernia Repair at a Day Surgery Clinic: Herniamed Registry Analysis after the 1St Year

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Herniamed, hernia, Lichtenstein, TAPP

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Abstract

Introduction. Abdominal wall hernias are the most common conditions requiring surgical treatment, and more than 30,000,000 hernia operations are performed worldwide each year. It is important to perform a follow-up and assessment of the treatment to improve the treatment outcome and reduce the rate of recurrences and postoperative pain. Clinical data documentation is crucial to facilitate tracking and data processing, and to ensure good clinical practice. For this purpose, there are several registers in Europe and worldwide. There is no national registry in Slovenia. The Iatros Medical Center has more than 20 years of experience in inguinal and umbilical hernia repair as a day surgery practice. Up to 300 hernia operations are performed each year, following official European Hernia Society guidelines. Since May 2020, we have been actively collaborating with the Herniamed registry, which is an online registry containing information on abdominal wall hernia operations. Registry is based on a standardized clinical approach, in which hernias are classified according to the current European Hernia Society classification.

Methods. From May 1st, 2020 to May 31st, 2021, we operated on 256 patients with inguinal hernias and 51 patients with umbilical hernias 20 to 91 years old, ASA 1–3. The Lichtenstein technique was used in 237 patients (230 unilateral and seven bilateral) and the transabdominal preperitoneal (TAPP) technique was performed in 19 patients (17 unilateral and two bilateral). Umbilical hernias were operated on following direct suture, the Mayo technique, and PVP mesh. Prophylactic antibiotics were given as a single preoperative dose of Cefamezin (cefazolin) 2 g. Two hundred and fifty patients were operated on under regional (spinal) anesthesia. All the patients were operated on as day surgery cases.

Results. Four patients (1.6%) with an inguinal hernia that were operated on with the Lichtenstein surgical technique had a re-

currence within the 1st year after surgery. One patient with open inguinal hernia repair (0.4%) was diagnosed with seroma postoperatively, managed conservatively.

Conclusion. The Herniamed registry is an important tool providing insight into collected data with the aim of assessing the results achieved and improving treatment. At our medical center, we follow European and global guidelines for the treatment of abdominal wall hernias, which have proven to be effective. Low rates of recurrence and postoperative complications were found in our series.

Introduction

The repair of ventral abdominal wall hernias is one of the most commonly performed operations. More than 30,000,000 hernia operations are performed worldwide each year. Despite the high frequency of surgical hernia procedures, the overall results are not at all satisfactory. Year after year, new hernia meshes and fixation techniques for these meshes appear on the market without their effectiveness having first been verified in clinical trials. It was only in 2009 that the first guidelines for treatment of inguinal hernias in adults were published by the European Hernia Society. It is important to perform a follow-up and assessment of the treatment to improve the treatment outcome and reduce the rate of recurrences and postoperative pain. The new internet-based English- and German-language registry for the entire spectrum of inpatient and outpatient hernia surgery is designed to improve the quality of patient care and provide valid data on outcome research. For this purpose, various hernia registries have been established (Herniamed, the Swedish Hernia Registry, EuraHS, and the Danish Hernia Registry).

There are two main approaches to inguinal hernia repair. These are broadly divided into standard and laparoscopic techniques. The minimally invasive laparoscopic techniques are transabdominal preperitoneal (TAPP) and total extraperitoneal (TEP) hernioplasty. One of the most frequently used standard techniques is Lichtenstein. Techniques recommended for umbilical hernia repair are placing non-absorbable mesh, or, for small hernias, suture repair.

The Iatros Medical Center has more than 20 years of experience in inguinal and umbilical hernia repair as a day surgery practice. Up to 300 hernia operations are performed each year, following official European Hernia Society guidelines. Since May 2020, we have been actively collaborating with the Herniamed registry.

The non-commercial company Herniamed was founded in 2009 to carry out an outcome research project in hernia surgery. This is a German-language network of surgeons with a special interest in hernia surgery. Thanks to the creation of an English-language version, it has already been expanded to an international network. The cornerstone of the Herniamed project is an internet-based registry into which all interested hospitals and surgeons can easily and quickly enter data on all hernia operations performed by them, using a scientifically corroborated standard approach. The database contains information on all types of abdominal wall hernias, such as inguinal, umbilical, incisional, epigastric, parastomal, and hiatus hernias. Patient data are saved only after obtaining consent, and they can be deleted at any time at the patient's request. Patient data recorded in the Herniamed registry are entered prospectively into special study forms by the treating surgeon. The registry contains data about the patient, operative data, complications, and pain. All hernias are encoded using the current European Hernia Society classification system. The hospitals and surgeons (practices) with access to the Herniamed registry can view their data at any time. All patients are followed up after 1, 5, and 10 years. On the follow-up date, the system generates a follow-up questionnaire.

Methods

From May 1st, 2020 to May 31st, 2021, we operated on 256 patients with inguinal hernias and 51 patients with umbilical hernias 20 to 91 years old, ASA 1–3. The median age of the patients was 55.5 years (range 20–91). Nine surgeons performed the operations. The Lichtenstein technique was used in 237 patients (230 unilateral and seven bilateral) and the TAPP technique was performed in 19 patients (17 unilateral and two bilateral). Umbilical hernias were operated on following direct suture, the Mayo technique, and PVP mesh. Prophylactic antibiotics are given as a single pre-

operative dose of Cefamezin (cefazolin) 2 g. Two hundred and fifty patients were operated on under regional (spinal) anesthesia. All the patients were operated on as day surgery cases. The patients were followed after 1 year. We used questionnaire to assess the outcomes.

Results

A total of four patients (1.6%) with an inguinal hernia operated on with the Lichtenstein surgical technique had a recurrence within the 1st year after surgery. Three patients (1.2%) operated on with the Lichtenstein technique had chronic pain after surgery, which was managed conservatively. One patient with an open inguinal hernia repair (0.4%) was diagnosed with seroma postoperatively and managed conservatively.

Discussion

Hernia surgery in particular has experienced rapid progress in recent years. In the surgical innovation process, a registry is an important tool that offers insights from the outset and merits evaluation. By continually evaluating and publishing results, it is possible to incorporate the very latest insights when deciding on the best treatment options for patients.

Conclusion

The Herniamed registry is an important tool providing insight into collected data with the aim of assessing the results achieved and improving treatment. Low rates of recurrence and postoperative complications were found in our series.

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