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Dear Colleagues,

Allow us to offer you a brief introduction to this issue of the journal Surgery and Surgical Endoscopy.

Hana Zavrtanik and Aleš Tomažič have written an excellent review article on the acceptance of minimally invasive (MI) techniques in complex pancreatic surgery, which involves exposure of the retroperitoneal gland, dissection around a major vascular structure, and management of an intricate organ. All of this results in a procedure associated with high morbidity. As far as laparoscopy is concerned, distal pancreatectomy has been widely adopted, both for benign and malignant pancreatic disease. Laparoscopic pancreaticoduodenectomy, however, is gaining slower acceptance due to its demanding resection and reconstruction phase. It is still limited to selected centers, which have been able to demonstrate promising results. Robotics, with a three-dimensional view, improved degree of movement, and elimination of hand tremor, were designed to overcome the limitations of conventional laparoscopy. The authors conclude that a learning curve is a clear obstacle to wider implementation of MI techniques, and that in order to ensure its safe adoption one must guarantee not only standardized training but also centralization of pancreatic surgery at specialized centers. Regarding robotics, one must also take into account cost analysis, which makes it difficult to justify the use of the robotic platform in the current healthcare environment.

Acute appendicitis (AA) is one of the most common abdominal emergencies worldwide. Urban Neudauer and Zdravko Štor present the results of a retrospective study of 1,153 patients with AA treated at their institution in a 2-year period. In a full 96.4% of them, a laparoscopic appendectomy (LA) was successfully performed. Through analysis of their excellent results, the authors conclude that LA is a safe and effective method, and as such it is the standard of care for the treatment of AA.

Sigmoid diverticulitis has increased in incidence over the past few decades, becoming a major healthcare burden for Western countries. Most cases undergo successful management in an outpatient setting with oral antibiotics and temporary restrictions. Among patients that must be hospitalized, some require surgical treatment. Bojan Krebs and Ana Šumah carried out a retrospective analysis of patients treated at their institution in a 5-year period. Almost half of the patients required surgical treatment. In two-thirds of operated patients, a non-restorative resection had to be performed, which proves that Hartman's procedure is still a valid standard of care treatment for Hinchey III and IV sigmoid diverticulitis.

Surgical therapy should preserve mobility as well as diminish the pain for patients suffering from arthritis. Katja Semprimožnik performed a retrospective review of patients undergoing proximal row carpectomy at her institution over a period of 3 years. Analyzing one's own results is very important, and Semprimožnik demonstrated their surgical treatment as a good salvage procedure for arthritic wrists. Moreover, a review of the literature shows her institution's results to be comparable to those at other medical centers.

Tomaž Jagrič presents a very interesting case report of a patient with a non-ampullary duodenal neuroendocrine tumor that needed salvage surgical resection after incomplete endoscopic resection. The patient was successfully treated with laparoscopic–endoscopic cooperative surgery, and the author believes that this procedure will be established as the treatment of choice for small low-grade NETs as well as incompletely resected NETs of the non-ampullary duodenum.

Radiation enteritis is a significant complication in patients receiving external beam radiotherapy (EBRT). The case report by Andrej Omejc et al. describes a 15-year-old female patient with skeletal metastases due to maxillary rhabdomyosarcoma. They performed a laparoscopic insertion of a tissue expander into the lower pelvis, thereby displacing the intestinal loops and thus crucially allowing an EBRT. Not only was the patient's initial recovery uneventful and the silicon implant removed easily after 6 weeks after EBRT, but the oncologic treatment itself was also successful. After a year of thorough follow-up, the disease is still in remission. The authors conclude that this method for displacing intestinal loops is effective, offers minimal morbidity, and thus should always be considered as an option for excluding the intestine from the pelvis.

Alja Matelič and Katja Semprimožnik present the case of a 4-year-old boy who suffered an injury to his right leg. Despite appropriate primary surgical treatment, the infection caused a skin defect with an exposed calcaneus bone, requiring a dermal matrix and a split-thickness skin graft. The treatment was successful, with both the aesthetic and functional outcome satisfactory.

In conclusion, describing the protocol of their new promising non-randomized study, Jan Grosek assesses the possible clinical implications of lymphatic mapping in colon cancer, using near-infrared indocyanine-green fluorescence imaging. This technology could hypothetically not only guide surgeons to adequate lymphadenectomy, but could even possibly obviate the need for an extended resection on the one hand or be an indication for it on the other. We sincerely hope you enjoy reading these articles as much as we did. Let us finish by encouraging you to consider the journal Surgery and Surgical Endoscopy for publishing your work.

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[2] Preclinical perfusion model comparing Ethicon CDH29P to Medtronic manual EEA2835, in which perfusion was not statistically significantly different between devices (p>0.005). Ethicon, PSB004557 A comparison of staple line perfusion between 29mm ECHELON CIRCULAR™ Powered Stapler (CDH29P) and manual 28mm DST Series™ EEA™ Circular Stapler (EEA2835), November 2016, Data on File (063163-161111)

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The Role of Minimally Invasive Pancreatic Surgery

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Review article

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Abstract

Laparoscopic pancreatic resections have been shown to be feasible and safe, with rising numbers being reported during the last decade. Although laparoscopic distal pancreatectomy has been widely adopted, laparoscopic pancreatoduodenectomy has gained slower acceptance due to the complexity of the procedure. Comparisons with open surgery have shown shorter hospital stays, reduced intraoperative blood loss, and similar results in terms of oncological adequacy. Due to improved postoperative recovery, a shorter median time to adjuvant chemotherapy and equal or even longer overall survival have been reported for minimally invasive resections. However, these data often represent experience from a single center or even a single surgeon and may not be generally applicable. Moreover, several studies have indicated that low patient volume leads to a longer hospital stay and higher costs, and can negatively impact outcomes. It has been shown that the expertise gained in laparoscopic and robotic procedures applied in other gastrointestinal areas does not necessarily ensure good outcomes for pancreatic resections. Pancreatic surgery, especially minimally invasive surgery, is associated with a steep learning curve. Experience in robot-assisted pancreatic surgery is increasing and is expected to improve surgical safety, but reports are few, lack randomization, and are mostly limited to dedicated centers. Importantly, minimally invasive pancreatic surgery must be provided with an advanced degree of expertise and should be performed in referral centers able to guarantee key services. This article reviews current literature regarding the value of minimally invasive pancreatic surgery, pointing out its benefits, limitations, and future prospects.

Introduction

The central retroperitoneal location of the pancreas and its close proximity to other visceral organs and major vascular structures makes pancreatic surgery technically challenging. Although perioperative mortality after pancreatic resections has decreased over the years, major morbidity still remains high, reaching 20 to 40% even in experienced hands (1). Minimally invasive techniques with their well-known advantages of providing less trauma, reduced pain, and faster return to daily activities have been increasingly applied to pancreatic resections during the last decade with the potential to improve postoperative recovery. These improved perioperative outcomes could be of great importance in patients with pancreatic adenocarcinoma, for whom improved recovery could mean earlier application of adjuvant therapy (2). However, concerns regarding the extensive learning curve exist, with possible increased postoperative morbidity during the implementation phase (3). Since the first reports of laparoscopic pancreatic resections in 1994, laparoscopic distal pancreatectomy (LDP) has been widely adopted and is now considered a treatment of choice, mainly for benign and low-malignant lesions in the distal pancreas (4, 5). On the other hand, laparoscopic pancreatoduodenectomy (LPD) has gained slower acceptance due to the complexity of the procedure (6). Experience in robot-assisted pancreatic surgery is increasing and is expected to improve surgical safety (7).

This article reviews current literature regarding the value of minimally invasive pancreatic surgery for the treatment of benign and malignant pancreatic lesions, discussing different techniques, their benefits, limitations, and future prospects.

Laparoscopic Distal Pancreatectomy

Distal pancreatectomy involves resection of pancreatic tissue to the left of the superior mesenteric vein–portal vein confluence. The first series of LDPs were described for the treatment of chronic pancreatitis (8). Because no anastomoses need to be formed laparoscopically, this approach was later widely adopted for benign, pre-malignant, and malignant disease of the pancreatic body or tail. Depending on the underlying disease process, different resection techniques were implemented. These were first described for an open approach (9–11) and were later shown to be feasible for minimally invasive surgery (12).

Spleen preservation is generally recommended in the case of non-malignant pancreatic disease (12–14) and can be achieved with splenic vessel preservation (e.g., the Kimura technique) or without (e.g., the Warshaw technique) (9, 10). During a spleen-preserving distal pancreatectomy, short gastric vessels and the left gastroepiploic artery must be preserved. The Warshaw technique yields a substantial success rate of splenic preservation in the laparoscopic approach, but some series have reported increased risk of spleen-related complications, such as perigastric varices, splenic infarction, secondary splenectomy, chronic abdominal pain, and prolonged hospital stay when compared to the Kimura technique (14–16).

In the case of malignant pancreatic disease, distal pancreatectomy should be extended to include subsequent splenectomy and resection of lymph nodes along the splenic artery, splenic hilum, and inferior border of the pancreatic body and tail (17, 18). A radical approach termed radical antegrade modular pancreatosplenectomy (RAMPS) was introduced by Strasberg et al. (11). This technique involves medial to lateral radical tumor resection combined with extensive lymph node dissection along the coeliac axis, common hepatic artery, and the retroperitoneal region, including resection of Gerota's fascia (anterior RAMPS) and optionally the left adrenal gland (posterior RAMPS) (12, 19). Posterior dissection is performed to a varying depth according to the tumor growth in order to achieve negative margins when the renal vessels, kidney, or adrenal gland are involved.

Several retrospective observational studies, systematic reviews, and meta-analyses comparing laparoscopic with open distal pancreatectomy (ODP) showed better short-term outcomes after laparoscopic resection with less blood loss, reduced length of hospital stay, and faster recovery. Nevertheless, the minimally invasive approach did not result in reduced postoperative morbidity, showing similar rates of overall complications and postoperative pancreatic fistula (1, 20–24). A higher rate of splenic preservation was reported in patients undergoing LDP, which was suggested to be due to easier dissection around the splenic

vessels under the magnification of laparoscopy (22–24).

Data on oncologic effectiveness (margin status, lymph node retrieval, and overall survival) are less often assessed because most reports comparing LDP to ODP consider both benign and malignant conditions (20, 23, 24). Laparoscopic distal pancreatectomy is still used selectively by some surgeons who consider the presence of malignancy to be a contraindication for laparoscopy (6). However, oncologic outcomes as measured by surrogate markers do not appear to be compromised. Stauffer et al. observed higher lymph node harvest in their laparoscopic group, although not reaching statistical significance (24). In a comparative analysis from the National Cancer Database, Sharpe et al. reported equivalent numbers of harvested lymph nodes, but patients undergoing LDP were less likely to have positive margins than patients after ODP, after controlling for age, facility type, tumor size, grade, stage, and neoadjuvant therapy (25).

Because most studies come from high-volume pancreatic centers, general application of their results is questionable. Moreover, selection bias may play a substantial role because more favorable patients were generally selected for the laparoscopic approach, causing overestimation of its benefits. The need for confirmation of these findings in a randomized controlled setting has been well recognized.

A multicenter patient-blinded randomized controlled trial was conducted by de Rooij et al., assessing the time to functional recovery in patients undergoing either open or minimally invasive distal pancreatectomy for symptomatic benign, premalignant, or malignant pancreatic disease without vascular involvement (26). In total, 111 patients were randomized. Minimally invasive distal pancreatectomy was associated with a 2-day reduction in time to functional recovery and better quality of life without increasing costs.

One of the study limitations is that only a minority of patients were treated for pancreatic ductal adenocarcinoma, which impedes the evaluation of oncologic outcomes. Previous studies showed that margin-negative resection with adequate or improved peripancreatic lymph node harvest is feasible using the laparoscopic approach and that the presence of malignancy should not contraindicate its use (25, 27). The DIPLOMA (Distal Pancreatectomy, Minimally Invasive or Open for Malignancy) trial is currently ongoing and aims to compare minimally invasive distal pancreatectomy to the open approach regarding the radical resection rate for pancreatic ductal adenocarcinoma in a multicenter randomized setting (28).

Laparoscopic Pancreatoduodenectomy

Pancreatoduodenectomy is performed for the treatment of lesions of the pancreatic head and periampullary region. Because it requires a demanding resection and reconstruction phase, it is considered one of the most challenging operations in gastrointestinal surgery (6). The complexity of this procedure dramatically limited the use of the minimally invasive approach, with questionable benefits for patients. However, with the advance of laparoscopic techniques and improved equipment, the number of laparoscopic pancreatoduodenectomies (LPD) performed is continuously rising (29, 30).

Different surgical approaches for minimally invasive pancreatoduodenectomy have been implemented. In the total laparoscopic approach, both the resection and reconstruction phase are performed intracorporeally, whereas in the laparoscopic-assisted approach the resection phase is done laparoscopically but the anastomoses are performed through a small incision, which is also used for specimen extraction (1). Moreover, robotic assistance can be used to facilitate laparoscopic reconstruction after the total laparoscopic approach (2).

In accordance with the biological rationale that laparoscopic procedures decrease surgical trauma and thus enhance postoperative recovery, several studies have reported potential advantages of LPD over the open approach in terms of blood loss, transfusion requirements, and total hospital stay (31–33). Although less delayed gastric emptying and reduced rates of surgical site infections were reported in some studies (2, 33–35), no difference between the two approaches was generally seen in overall postoperative morbidity and mortality (31, 36). However, some concerns have been raised because increased rates of postoperative pancreatic fistula (35, 37, 38) and 30-day mortality (29, 30, 31, 39) were reported after LDP when compared to open pancreatoduodenectomy (OPD), main-

ly at low-volume centers. In their matched-cohort analysis, Dokmak et al. reported significantly higher rates of clinically relevant (grade C) postoperative pancreatic fistula after laparoscopic versus open resection (24% vs. 6% for LPD and OPD, respectively) (37). Furthermore, a large National Cancer Database study including more than 7,000 patients reported significantly higher postoperative 30-day mortality for patients undergoing LPD compared to those who underwent open resection (29). Although not statistically significant, an inverse association of hospital case volume (≤ 10 minimally invasive pancreatoduodenectomies / 2 years) with 30-day mortality was observed. An analysis of the same database found that LPD was associated with more than twice the risk of mortality compared with OPD (7.5% vs. 3.4% for LPD and OPD, respectively) in hospitals performing < 10 LPDs / 2 years. In contrast, 30-day mortality in hospitals performing > 10 LPDs did not differ between the laparoscopic and open approach (39). These findings highlight that the introduction of LPD should be supervised carefully and probably only used in high-volume centers.

To confirm the results of previous studies in a randomized controlled setting, three randomized controlled trials comparing outcomes after LPD vs. OPD have been conducted so far.

The PLOT and PADULAP single-center trials randomized 32 and 66 patients, respectively, to undergo either open or laparoscopic resection (40, 41). The primary endpoint was the length of hospital stay, which was significantly decreased in the laparoscopic group in both studies (7 vs. 13 days and 14 vs. 17 days). Reduced rates of overall complications after LPD but similar pancreas-related morbidity and overall mortality were reported in the PADULAP trial. However, no difference with regard to the aforementioned outcomes was found between the two groups in the PLOT trial.

These findings are contrary to the recent LEOPARD-2 trial—a multicenter, patient-blinded randomized controlled trial comparing LPD to OPD performed in a setting of trained surgeons at specialized pancreatic centers (42). The trial was prematurely terminated due to a potentially higher 90-day mortality rate in the LPD group (10% vs. 2%, $p = 0.20$). The authors included 99 patients (from an initially planned 136 patients) and found no differences in time to functional recovery, postoperative complications, costs, and quality of life. Similar to previous reports, including the PLOT and PADULAP trials, LPD was associated with longer median operative times and lower blood loss. In addition, major postoperative complications and pancreas-specific complications were comparable between the two groups. For comparison, reported mortality rates were 3% versus 3% in the PLOT trial, and 0% versus 7% in the PADULAP trial for laparoscopic and open resection, respectively.

Given that the majority of pancreatoduodenectomies are performed for malignant or premalignant lesions, adequate oncological resection remains another key question. The results of several comparative studies showed equivalent oncologic outcomes in terms of margin status and lymph node yield in patients undergoing OPD vs. LPD for adenocarcinoma. These data suggest that the minimally invasive approach can be used outside of benign indications for pancreatic resection (29, 30, 36, 37, 39). Croome et al. suggested a potential oncological advantage of minimally invasive pancreatoduodenectomy showing shorter median time to adjuvant chemotherapy in LPD when compared to OPD (2). Moreover, the proportion of patients who did not receive adjuvant chemotherapy due to poor functional status or complications was lower after laparoscopic resection. Although there was no significant difference in overall survival between the two groups, improved progression-free survival was observed in the laparoscopic group.

Laparoscopic pancreatoduodenectomy has been described for all indications, even locally advanced malignant disease invading surrounding organs or vascular structures (43). However, most large series exclude patients with very large tumors, vessel infiltration, substantial preoperative comorbidity, a history of abdominal surgery, or a very high BMI (36, 44). Despite a few studies demonstrating favorable outcomes of laparoscopic resections, these findings should be interpreted with caution (31). For example, in their retrospective cohort study, Kuesters et al. reported significantly higher tumor-free resection margins in their laparoscopic group (87% vs. 71%) (36). However, these findings could be explained by selection criteria for a laparoscopic approach as contraindications for minimally invasive resection were clear signs of vascular infiltration, borderline resectability of the tumor, and previous abdominal surgeries.

The majority of studies focus on short-term surrogates of oncologic outcome—namely, lymph node yield and margin status—and the exact clin-

ical relevance of these findings is yet to be determined. The quality of oncologic resection is best shown by overall survival, but data on long-term oncologic results are scant. In a systematic review conducted by Kendrick et al. (31), only one study was found that reported local recurrence rates and overall survival (2). Conrad et al. performed a propensity score weighting analysis to assess long-term oncologic outcomes for patients with adenocarcinoma undergoing LPD vs. OPD (44). They reported 1-, 3-, and 5-year overall survival rates of 82.5, 50, and 38.6% for LPD and 76, 44, and 28% for OPD, but the difference did not reach statistical significance. Similarly, Kuesters et al. reported a non-significant trend toward improved 5-year survival in their laparoscopic group (20% vs. 14% for the laparoscopic and open procedure, respectively, $p = 0.51$) (36).

Based on the current literature, laparoscopic resection of pancreatic adenocarcinoma seems to aim at improving patient-centered outcome (quality of life) and not increasing overall survival. Patient selection may be the most important factor for optimizing the advantages of the laparoscopic approach with this complex surgical procedure. Tumor size seems to be less important than tumor localization because portal or superior mesenteric vein infiltration increases the risk of conversion during the resection. These patients may thus not benefit from the minimally invasive approach.

Robot-Assisted Pancreatic Resections

The technical challenges of laparoscopic pancreatic resections have prompted the use of robotic assistance, which was designed to overcome the limitations of conventional laparoscopy. Robotic platforms offer three-dimensional high-definition vision with extended degrees of freedom of movement and improved ergonomics. This allows steadier and more precise manipulation of tissues, leading to potential benefits as compared to both the laparoscopic and open approaches.

Several reports have confirmed the safety and feasibility of the robotic approach, showing similar advantages as with laparoscopic surgery when compared to the open approach, such as less blood loss and a shorter hospital stay with an equivalent morbidity rate (45). On the other hand, robot-assisted resections have been criticized due to longer operative times, higher cost, and non-superiority in oncologic outcomes (7).

Robot-Assisted Distal Pancreatectomy

For distal pancreatectomy, robotic assistance was shown to be safe and feasible with equivalent postoperative outcomes in terms of postoperative morbidity, mortality, length of hospital stay, and readmission rates when compared to conventional laparoscopy (46–51). At the same time, enhanced visualization and improved dexterity provided by the robotic platform resulted in higher spleen preservation rates, decreased blood loss, lower rates of conversion to open surgery, and improved oncological radicality, as reported in some studies (46, 48, 50, 51). However, because the majority of studies are retrospective comparative single-center case series with a relatively small sample size prone to selection bias, it is still not clear whether the robotic approach provides additional advantages for patients, particularly in cases in which splenic preservation is not indicated.

Daouadi et al. (46) retrospectively compared 30 robot-assisted distal pancreatectomies (RDPs) to 94 LDPs and observed no conversions to open surgery in the robotic arm (compared to 16% in the laparoscopic group). This was observed despite the fact that more complex cases were undertaken in the robotic cohort, including a significantly greater proportion of patients with pancreatic ductal adenocarcinoma and patients who had undergone previous abdominal surgery. Moreover, 50% of the conversions in LDP were for pancreatic ductal adenocarcinoma and resulted in a 35% margin-positive rate, suggesting that the laparoscopic approach was inferior for this disease. Conversely, a 100% R0 resection margin rate was reached with robotic assistance. Blood loss was comparable between the two groups; however, among patients in the top quartile of perioperative blood loss, significantly lower blood loss was observed in RDP (375 ml vs. 550 ml for RDP vs. LDP, respectively), indicating improved control of major hemorrhage.

Similarly, in their meta-analysis, Xu et al. (50) showed a slight technical advantage of the robotic approach, including conversion and splenic vessel conservation rates. Although spleen preservation rates were comparable between the two groups, splenic vessel preservation was achieved more

frequently in RDP. This is important because preservation of splenic vessels decreases the risk of postoperative splenic infarction when compared to splenic vessel ligation.

Despite these benefits, the significant cost of robotic instrumentation combined with a longer operative time makes it difficult to justify the use of the robotic platform in the current healthcare environment. However, the studies are inconclusive on these two topics. Docking the robot and intraoperative instrument exchange may extend the operation time, but in a meta-analysis by Xu et al. (50) RDP was not any more time-consuming. Furthermore, Daouadi et al. (46) even observed significantly decreased operative times in the robotic group (293 vs. 371 minutes in RDP and LDP, respectively). This was suggested to be due to better three-dimensional visualization and flexible motion of EndoWrist instruments, allowing better performance in tissue manipulation and thereby easier and faster pancreas and spleen mobilization as well as vascular control. Robotic assistance was generally associated with an approximately two-fold increase in cost when compared to conventional laparoscopy (47, 49, 50). However, in view of promising oncologic results and other benefits, this approach should not be abandoned, as suggested by Souche et al. in their cost-effectiveness analysis (49). Easier access and cost reduction of this technology is expected in the future, thereby possibly expanding the field of robotic approach to more complex corporeal or distal pancreatic lesions, which have so far been treated with open surgery.

Robot-Assisted Pancreatoduodenectomy

Considering pancreatoduodenectomy, the advantages of the robotic platform mentioned above could aid in lymph node harvesting, the Kocher maneuver, dissection of hepatic hilum structures, duodenal mobilization, and fine dissection of the portal vein and superior mesenteric artery. Furthermore, in the reconstruction phase of the procedure, the three-dimensional view, improved degree of movement, and elimination of hand tremor and fulcrum effect of rigid laparoscopic instruments proved to be extremely useful when performing anastomosis, especially pancreato- and hepaticojejunostomy. However, due to a lack of evidence-based quality data, the true benefit of the robotic approach for this operation remains to be demonstrated.

Several reports have shown promising results, comparable to and at times better (in conversion rate and hospital stay) than conventional laparoscopy and open surgery.

When compared to OPD, robotic assistance was associated with decreased blood loss and a shorter hospital stay but similar morbidity and mortality rates (46-52). Cai et al. analyzed single-center outcomes of 865 consecutive open and robotic pancreatoduodenectomies (RPD) performed by surgeons well beyond their learning curve for both open and robot-assisted pancreatic surgery. They found statistically lower rates of clinically relevant pancreatic fistula in the robot group (15.8% vs. 5.7%, $p < 0.001$) (56). Moreover, a higher number of lymph nodes harvested and R0 resection rate was achieved in RPD (53, 54). Although tumor size did not differ between the two approaches, more favorable lesions tend to be operated on in a minimally invasive fashion, which highlights the importance of proper patient selection to obtain favorable outcomes. Watkins et al. (57) conducted a study among five high-volume pancreatic centers during the period of implementation of RPD, including a maximum of 20 cases at any site in order to quantify the immediate risk of adopting this new approach. Except for longer operative times, all other outcomes were equivalent to open surgery as reported in the literature, even during the early phase of adoption.

Robot-assisted pancreatoduodenectomy appears to offer some advantages compared to conventional laparoscopic surgery, although data comparing these two approaches are scant. Even though dexterity is improved by the robotic approach, no reduction in postoperative complications can presently be demonstrated compared to LPD. Retrospective comparative study of LPD and RPD performed by Liu et al. showed significantly shorter operative time, hospital stay, and less blood loss in the robot-assisted group whereas no significant difference was observed between the two groups in terms of overall complication and mortality rates (58). Nassour et al. abstracted 235 LPDs and 193 RPDs from the National Surgical Quality Improvement Program database and found no difference in operative time, reoperation rate, length of hospital stay, 30-day mortality, and overall and major morbidity between the two approaches (59). However, RPD showed the advantage of a lower conversion rate (11.4% vs. 26.0% for RPD and LPD, respectively). Interestingly, in a systematic review and network meta-analysis comparing

different minimally invasive pancreatoduodenectomy techniques, Ricci et al. showed the total robotic approach to have the best safety/efficacy ratio of all minimally invasive techniques, being the best choice in terms of overall complication rates, reoperation rates, mean harvested lymph nodes, and margin-negative resection rates (60). Both laparoscopic approaches (total laparoscopic and with hand-assisted reconstruction phase) seemed to be inferior to the robotic and open procedures in their analysis.

Nevertheless, data presently available in the literature do not support the use of robotic assistance for pancreatoduodenectomy compared to the laparoscopic or open approach. The reason for this might be the low number of reported cases. According to Zureikat et al. (61), real advantages in terms of operative time, postoperative morbidity, and oncological results were shown after 80 pancreatoduodenectomies, which was not attained in most of the published series. Therefore, satisfying results could potentially be achieved after a wider spread of robotic pancreatic surgery, with a longer follow-up as well as prospective randomized studies for patients undergoing RPD for pancreatic cancer.

Learning Curve

The learning curve of minimally invasive pancreatic surgery is an important barrier to its implementation. As mentioned before, surgical safety has been a problem in hospitals with low patient volume (< 10 procedures per year), reporting increased postoperative pancreatic fistula and mortality rates after LPD when compared to the open approach (29). Due to the high specificity of pancreatic surgery, expertise gained in laparoscopic and robotic procedures in other gastrointestinal areas does not ensure good outcomes after pancreatic resections. The learning curve of minimally invasive pancreatic surgery depends on the surgeon's experience in open pancreatic resections and advanced gastrointestinal laparoscopy as well as the intensity and quality of laparoscopic training.

The most common indicators of the learning curve reported in the literature are decrease in operative time, estimated blood loss, and conversion rates (62–67). As progress is made along the learning curve, surgical complexity is increased without worsening operative outcomes. The number of procedures needed to overcome the learning curve for minimally invasive pancreatic resections differs among the studies.

Laparoscopic Distal Pancreatectomy

For laparoscopic distal pancreatectomy, a cutoff of 10 procedures has been suggested to complete the learning curve (62). In most series, a reduction in operative time and conversion rate was reported after 10 to 20 procedures among surgeons with extensive experience in pancreatic surgery and advanced laparoscopic techniques treating patients at a tertiary pancreatic center (63–67). However, de Rooij et al. (68) warned against the traditional parameters that are used to describe the impact of the surgical learning curve, suggesting that other data (postoperative morbidity, mortality, hospital stay, and readmission rates) are needed to assess the various parts of surgical proficiency gain. In their series of 111 laparoscopic distal pancreatectomies, the authors reported no change in operative time or blood loss throughout the observation period, although surgical complexity increased. As experience was gained, more aggressive and complex tumors (pancreatic ductal adenocarcinomas and T3/T4 pancreatic tumors requiring multivisceral resection) were undertaken.

Robot-Assisted Distal Pancreatectomy

Similar to the laparoscopic technique, Napoli et al. showed a clear reduction in operative time after the first 10 RDPs, despite increasing rates of malignant histology (69). However, another report identified the learning curve of RDP to be approximately 40 cases, observing a significant reduction in operative time and 90-day readmission rate (70). Although non-significant, reduction in clinically significant grade B or C fistulae incidence and major postoperative complication rates was additionally observed after 40 cases. The surgical team comprised three surgeons with extensive prior experience in open and laparoscopic pancreatic surgery but minimal experience with the robotic platform. Thus, basic familiarity with the platform, including optimal port placement, robotic docking, and an initial rapid improvement in dissection skills, was needed first, thereby probably prolonging the actual learning curve.

Laparoscopic Pancreatoduodenectomy

The learning curve for LPD has been estimated to be between 30 and 80 procedures (62). Nagawaka et al. showed stabilization of operative times and blood loss after 30 cases (71). Similarly, Kim et al. performed an analysis of 100 LPDs and reported that the total operation time decreased significantly when comparing their initial 33 cases (9.8 hours) to the last 34 cases (6.6 hours) (72). In addition, a decrease in complication rate and mean hospital stay was also observed. Wang et al. concluded that a minimum of 40 cases are required for a laparoscopic surgeon with a certain degree of experience to attain technical competence in LPD (73). A hybrid approach was suggested to be performed during the initial experience of LPD to ensure safe and efficient implementation of the total laparoscopic approach (74). This advice allows development of proficiency in laparoscopic dissection, which can then be applied to reconstruction and anastomoses with less challenge. The authors reported reduced operative times after 10 procedures, and significantly lower operative time and estimated blood loss when compared to the traditional open approach were observed after 50 procedures.

Robot-Assisted Pancreatoduodenectomy

Robot-assisted pancreatoduodenectomy could be expected to have a shorter learning curve when compared to LPD due to enhanced dexterity. However, robotic surgery is associated with unique struggles such as complete loss of haptic feedback and lack of direct visual control over instrument position, which require adaptation and careful team cooperation (75). Napoli et al. showed a decrease in operative time after 33 RPDs, but they suggested that the number of operations could vary based on individual surgeon and institutional experience (76). Similarly, Zhang et al. reported completion of a learning curve after 40 procedures (77). Boone et al. analyzed 200 cases, showing that the learning curve needed to attain proficiency in RPD was approximately 80 procedures (78). In their series, conversion rate to open surgery and estimated blood loss improved after 20 procedures, decrease in pancreatic fistula was observed after 40 procedures, but overall efficiency, as measured by operative time, took longer: up to 80 procedures. However, this might not be attributable solely to the learning curve of the attending surgeon because trainees played an increasing role throughout the experience and were given responsibility for key portions of the procedure.

Minimally Invasive Training Paradigms

Learning curve identification is clearly important in order to evaluate quality and patient safety during implementation of new surgical procedures as well as to guide surgical training.

Minimally invasive pancreatic surgery is associated with a long learning curve. Given the low number of pancreatic resections in most centers, surpassing the learning curve of open surgery, let alone minimally invasive pancreatic surgery, remains a challenge during traditional training paradigms. Therefore, complete centralization of these procedures at centers of excellence as well as evidence-based structured implementation programs with deliberate training are needed to prevent increased morbidity and mortality (3). One example is the nationwide deliberate training program LAELAPS (Longitudinal Assessment and Realization of Minimally Invasive Pancreatic Surgery) initiated by the Dutch Pancreatic Cancer Group in order to safely implement minimally invasive pancreatic surgery in the Netherlands. It includes standardized detailed technique description, video training, and proctorship in minimally invasive distal pancreatectomy and pancreatoduodenectomy (79, 80). After training introduction in 2014, a significant increase in the use of minimally invasive pancreatic surgery with improved patient outcomes was observed. Of the 91 hospitals in the Netherlands, pancreatic surgery is currently centralized at 17 hospitals, which all perform a minimum of 20 pancreatoduodenectomies annually.

Conclusion

Pancreatic resections are complex and highly morbid procedures with long learning curves. Reports from high-volume centers provide important data on the benefits of minimally invasive pancreatic surgery when performed in an ideal setting, such as reduced blood loss, reduced length of hospital stay, and equivalent short-term morbidity and

mortality. Currently, enough evidence appears in the literature to postulate that LDP should play a more standard role, with open surgery being preferred only in cases of significant chronic inflammation or a large lesion in direct proximity to the coeliac truncus. However, data on LPD are less convincing. Safe adoption of these complex procedures requires adequate training involving a standardized approach and proctorship as well as comparative measurements of results. Centralization of pancreatic surgery at specialized clinics that allow technical development and guarantee all key services is crucial.

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Proximal Row Carpectomy: Comparing Pre- and Postoperative Wrist Status

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Abstract

Background. Proximal row carpectomy is a salvage procedure for arthritic wrists. According to the published literature, the operation preserves mobility and diminishes pain. We compare the outcomes of patients who were operated on at our department to postoperative outcomes published in the literature.

Methods. A retrospective review of patients undergoing proximal row carpectomy in our hospital in the last 3 years was performed. All the patients were invited for a follow-up. At the follow-up visit, the movement and strength of both wrists were measured. The patients also completed a short questionnaire. Pre- and postoperative measurements on the operated and un-operated wrist were compared. A literature search regarding proximal row carpectomy was performed.

Results. Mobility of the operated wrist before and after operation, grip strength before and after operation, mobility of the operated and unoperated wrist, and grip strength of the operated and unoperated hand were compared. After the surgery, dorsal flexion, volar flexion, ulnar deviation, radial deviation, and active range of motion were 128%, 90%, 97%, 88%, and 97% of the preoperative value, respectively. On average, spherical grip strength was 71% of the preoperative measurements, and cylindrical grip strength was 83% of the preoperative value. Patients achieved 77% of the preoperative grip strength and 66% preoperative finger strength. For the patients whose non-dominant hand was operated on, dorsal flexion and volar flexion were 75% and 66% of the unoperated hand, respectively. Patients whose dominant hand was operated on had dorsal flexion, volar flexion, and ulnar and radial deviation of 57%, 58%, 66%, and 46% of the contralateral side, respectively. On average, power grip and finger strength were 56% and 80% of the unoperated hand, respectively.

Conclusion. Proximal row carpectomy successfully diminishes pain and preserves mobility in patients with partial wrist arthrosis. Postoperative results in our hospital are comparable to those at other medical centers.

Introduction

Arthrosis of the wrist is a chronic condition causing limited mobility of the hand, pain, and therefore problems at work and in everyday life. There are several different operative procedures to alleviate the pain, some retaining the mobility of the wrist, and some diminishing it. The treatment varies from radial styloidectomy when only the distal scaphoradial joint is affected to complex procedures when arthrosis has progressed to the proximal pole of the scaphoid or other wrist articulations. Treatment options are extensive denervation of the wrist (1), total wrist arthrodesis (2), excision of the affected scaphoid and intercarpal arthrodesis (3, 4), or proximal row carpectomy (PRC) (5). Each option is appropriate for selected patients.

In recent years, several reports have described the use of PRC for the treatment of acute wrist injuries, such as in hand replantation, open wrist injury with significant bone loss or articular surface damage, and irreducible or unsuccessfully reconstructed perilunate injuries (6). Various authors have reported good results after PRC, mostly comparing operated and unoperated hands.

In this study, postoperative results of patients who underwent PRC at the Department of Reconstructive, Plastic, and Hand Surgery at Celje General Hospital were analyzed comparing unoperated and operated wrists. In addition, the status of the wrist before and after the surgery were also compared, postulating that, because arthrosis is a chronic condition, improvement of the mobility and strength of the arthritic wrist is achieved with surgery, which cannot be confirmed by comparing solely unoperated and operated hands. A literature search was performed, and our results were compared to those in the literature.

Methods

A retrospective analysis of patients who underwent PRC at the Department of Reconstructive, Plastic, and Hand Surgery at Celje General Hospital from January 2010 to December 2012 was performed. All patients were invited for a follow-up. During the follow-up, the patients underwent measurements of the mobility of both wrists and strength measurements of both hands. The patients also completed a short questionnaire about their level and frequency of pain, problems at work, leisure activities, and everyday life—all questions comparing status before and after the operation. Measurements of the mobility and strength of the operated wrist and hand before and after the operation were compared.

Results

Twenty-two patients underwent PRC in a 2-year period. Eleven patients had scaphoid non-union with local arthrosis or scaphoid non-union advanced collapse (SNAC), three patients were diagnosed with arthrosis, three patients had acute perilunate dislocation, one patient had chronic scapholunate dissociation, and four were treated with PRC because of an unsuccessful previous operation. The average age at the time of operation was 40 years (range 18–75 years). All patients had an X-ray preoperatively, twelve had CT, and five of them also had MRI. Only MRI was performed in five patients. Half of the patients had preoperative range of movement and strength measurements done.

Thirteen patients responded to our request for evaluation of the wrist for this study, two of them had only partly completed strength and mobility measurements (acute injury of the other hand), and two more completed a short questionnaire. Seven of the responding patients were treated because of scaphoid non-union, two were treated for partial arthrosis of the wrist, three were treated after previous unsuccessful operation (scaphoid fracture and scapholunate ligament reconstruction), one had chronic scapholunate dissociation, and two were treated for perilunate dislocation. Eight patients were treated on the non-dominant hand and five on the dominant hand. The average age of the responding patients was 36 years at the time of the operation (range 18–62 years).

At a follow-up visit, on average 19.9 months (range 9–35 months) postoperatively, mobility and grip strength of both wrists and hands were measured. Patients also answered questions about pain in the wrist, work, and everyday life limitations. The mobility of the operated wrist before and after operation, grip strength before and after operation, mobility of the operated and unoperated wrist, and grip strength of the operated and unoperated hand were compared.

Measurements of mobility of the operated wrist are shown in Table 1. Seven of the operated patients who responded to the request for follow-up had preoperative measurements done. Mobility measurements of the operated wrist before and after operation showed improved dorsal flexion in three patients (176% of the preoperative mobility). An unchanged range of motion was detected in one patient, and a diminished range of motion was shown in three patients (80% of the preoperative). On average, postoperative dorsal flexion was 128% of the preoperative value. Volar flexion improved in two patients (122% of the preoperative), remained unchanged in two patients, and was diminished in three patients (63% of the preoperative). On average, volar flexion was 90% of the preoperative value. Ulnar deviation was mostly diminished (76% of the preoperative), unchanged in one patient, and improved in one, on average 97% of the preoperative value. Radial deviation was diminished to zero degrees in two patients, 50% of the preoperative value in one patient, unchanged in one patient, and improved in three patients (156% of the preoperative); on average it was 88% of the preoperative measurements. Active range of motion (AROM) from volar to dorsal flexion was diminished in three patients (82% of the preoperative), unchanged in two patients, and improved in two patients (117% of the preoperative). Preoperative AROM was 76 degrees, and after operation it was 73 degrees. On average, it was 97% of the preoperative AROM.

Strength measurements before and after the operation are shown in Table 2. Spherical and cylinder strength are different modes of grip strength, and lateral and pulp to pulp pinch are different modes of finger fine movement grip. Strength measurements showed some patients retaining or even improving preoperative power grip strength. On average, spherical grip strength was 71% of the preoperative measurements, and cylindrical grip strength was 83% of the preoperative value. Patients achieved 77% of the preoperative grip strength. Finger strength was also improved in some patients; however, the values reached on average 66% of the strength before the operation (range 0–150% of the preoperative value).

Next, we compared the mobility of the operated and contralateral hand. The results are shown in Table 3. The first half of the table (nos. 1–7) are patients operated on the nondominant hand. One patient (no. 3) was found with better mobility of the operated hand; this patient had bilateral scaphoid non-union, was operated on the non-dominant hand, and is now awaiting PRC of the other wrist. Dorsal flexion was diminished to 75% of the contralateral unoperated wrist and volar flexion was diminished to 66%. Half of the patients were found with better or the same ulnar deviation compared to the contralateral side, and half had on average 55% ulnar deviation of the contralateral side. Radial deviation was the same or improved in half of the patients, two had no radial deviation, and two had diminished radial deviation (at 37%) of the contralateral side. The active range of motion was 141 degrees in the unoperated wrist and 81 degrees in the operated wrist, or 61% of the contralateral unoperated

Table 1. Measurements of motion of the operated wrist before and after proximal row carpectomy. No. = patient number, Pr = preoperative (°), Po = postoperative (°), AROM = active range of motion.

	Dorsal flexion			Volar flexion			Ulnar deviation			Radial deviation			AROM		
No.	Pr	Po	%	Pr	Po	%	Pr	Po	%	Pr	Po	%	Pr	Po	%
1	55	45	81	50	50	100	35	30	85	10	5	50	105	95	90
2	10	25	250	40	25	55	15	10	66	5	0	0	50	50	100
3	35	45	128	40	30	75	30	25	83	10	5	200	75	75	100
4	45	40	88	40	40	100	10	20	200	10	15	150	85	80	94
5	35	25	71	50	30	60	15	15	100	10	0	0	85	55	64
6	40	40	100	30	40	133	15	10	66	5	5	100	70	80	114
7	20	30	150	45	50	111	30	25	83	25	30	120	65	80	120

Table 2. Strength measurements before and after proximal row carpectomy.
No. = patient number, Pr = preoperative, Po = postoperative.

No.	Power grip, spherical (bar)			Power grip, cylinder (kg)			Lateral pinch (kg)			Pulp to pulp pinch, thumb to index, 2 kg (kg)			Pulp to pulp pinch, thumb to index, 3 kg (kg)			Pulp to pulp pinch, thumb to little finger (kg)		
	Pr	Po	%	Pr	Po	%	Pr	Po	%	Pr	Po	%	Pr	Po	%	Pr	Po	%
1	0.7	0.3	42	40	30	75	11	11	100	6.5	6.5	100	3.5	2.5	71	0.7	0.5	71
2	0.4	0.5	125	20	5	25	2.5	0.75	30	2	0	0	2	0	0	1.5	0	0
3	0.1	0	0	20	15	75	4.5	1.75	38	2	2	100	1	0.75	75	1.5	0	0
4	1	0.9	90	58	58	100	11	10	90	5.5	6.5	84	2	3.5	57	2	3.5	57
5	0.4	0.4	100	35	50	142	5	8	160	3	2	66	2.5	2	80	1	1.5	150

wrist without counting the patient whose mobility was better because of bilateral involvement of the wrist. Patients whose dominant hand was operated on had dorsal flexion 57%, volar flexion 58%, ulnar deviation 66%, and radial deviation 46% of the contralateral side. The active range of motion was 55% of the contralateral side, on average 78 degrees compared to 134 degrees of the unoperated side. The average dorsal flexion was 68%, volar flexion 63%, ulnar deviation 80%, radial deviation 54%, and AROM 79 degrees, 64% of the contralateral side. There was no significant difference in patients whose dominant or non-dominant hand was operated on when comparing the mobility of the wrist with the contralateral side.

Strength measurements comparing operated and unoperated hands are shown in Table 4. On average, power grip was diminished and was 56% of the unoperated hand. Finger strength was 80% of the unoperated hand. Because power grip strength was lower than published in different articles, we

Table 3. Measurements of motion after proximal row carpectomy of operated and unoperated wrist.
No. = patient number, Op = operated wrist (°), No = unoperated wrist (°), AROM = active range of motion.

No.	Dorsal flexion			Volar flexion			Ulnar deviation			Radial deviation			AROM		
	Op	No	%	Op	No	%	Op	No	%	Op	No	%	Op	No	%
1	45	80	56	50	70	71	30	30	100	5	20	25	95	150	63
2	25	50	50	25	60	41	10	30	33	0	15	0	50	110	45
3	45	30	150	30	30	100	20	15	133	15	10	150	75	60	125
4	40	70	57	35	75	46	15	30	50	0	20	0	75	145	51
5	30	45	66	40	50	80	20	15	133	10	10	100	70	95	73
6	70	70	100	60	80	75	30	30	100	20	20	100	130	150	86
7	35	70	50	35	65	53	25	30	83	10	20	50	70	135	51
8	30	70	42	50	80	62	25	30	83	5	20	25	80	150	40
9	55	65	84	35	75	46	20	30	66	15	20	75	90	140	64
10	25	60	41	30	60	50	15	30	50	0	20	0	55	120	45
11	45	70	64	40	60	66	30	30	100	20	20	100	85	130	65
12	40	70	57	40	60	66	10	30	33	5	15	33	80	130	61

Table 4. Strength measurements after proximal row carpectomy, operated and unoperated hand. No. = patient number, Op = operated wrist, No = unoperated wrist.

	Power grip, spherical (bar)			Power grip, cylinder (kg)			Lateral pinch (kg)			Pulp to pulp pinch, thumb to index, 2 kg (kg)			Pulp to pulp pinch, thumb to index, 3 kg (kg)			Pulp to pulp pinch, thumb to little finger (kg)		
No.	Op	No	%	Op	No	%	Op	No	%	Op	No	%	Op	No	%	Op	No	%
1	0.18	0.8	22	26	52	50	8.5	10.5	80	3.5	5.25	66	1.5	3.25	46	0.15	0.5	30
2	0.38	1.3	29	30	68	44	11	13	84	6.5	9	72	2.5	3	83	0.5	1	50
3	0.05	1	5	5	48	10	0.75	4.5	16	0.5	4	12	0	2.75	0	0	1.5	0
4	0	0.2	0	15	25	60	1.75	3	58	2	2	100	0.75	1.75	42	0	1.75	0
5	0.4	1	25	40	54	74	10	13	76	6	9	66	4	5	80	1	3	33
6	0.3	0.94	31	30	46	65	5.5	10	55	5	6	83	2	4	50	1	1.5	66
7	0.9	1.4	64	58	80	72	10	11	90	6.5	6.75	96	3.5	3.5	100	1.25	1.5	83
8	0.58	1	58	50	50	100	7.5	8.5	88	5.5	4	137	2.5	2	125	1	0.25	400
9	0.4	0.5	80	50	48	104	8	10	80	2	1.5	133	2	2	100	1	1	100
10	0.68	0.7	97	32	32	100	6.5	5.75	113	3.75	3.5	107	3.25	3.5	92	1.25	1.75	71
11	0.65	1.1	59	50	54	92	9	8.5	105	5	5.5	90	3	2.75	109	1	1.5	66

separated operated patients into non-dominant hand (nos. 1–6) and dominant hand (nos. 7–11). Patients whose non-dominant hand was operated on showed highly diminished grip strength: spherical 18%, cylindrical 50%, on average 34% of the contralateral. Finger strength was 53% of the unoperated dominant hand. Patients whose dominant hand was operated on showed greater remaining strength: average spherical 71%, cylindrical 93%, average both strengths together 82% of the contralateral hand. Fine touch strength was greater in most patients, on average 114% of the unoperated non-dominant hand.

We asked the patients about subjective feelings, everyday life, and pain before and after the operation rated on a scale from 0 (no pain) to 10 (most excruciating pain imaginable). As expected, both patients with perilunate luxation had no pain prior to the operation but reported experiencing pain of level 2 and up to level 7 after the operation. One patient described pain as being present during certain movement, and the other felt pain when loading the wrist. The patient who felt pain up to level 7 is now unemployed, partly because of problems with his hand and partly because of other health issues. He also complained of having a lot of problems in everyday life. The other patient was unemployed before the accident; now he has a job, he is still active in all his leisure activities (motocross and playing musical instruments), and he has no problems in everyday life.

Patients with arthritic changes rated the pain before the operation on average as 8 (range 3–10), the pain being present every day without triggering activity. After the operation, patients rated pain on average as 3 (range 0–6), the pain being present only while loading the hand or during certain movements. Nine patients changed jobs after the operation. Two patients were regularly retired, one patient got a job (was unemployed before the operation), one patient was promoted, and one patient had minor problems with the operated hand but changed work due to other health problems. Four patients had to change their job because of less strength and occasional pain (two worked as roofers and are now limited at work because of a height hazard; one worked as a driver who was also responsible for unloading, and one was working on a conveyor belt; both are now employed as dispatchers). One patient lost his job partly because of his hand impairment and partly because of other injuries (falling from a height). Patients mostly do the same leisure activities as they did before the operation; only one patient changed the

sports he engaged in during his leisure time. Four patients partly changed their leisure activities (a different position while playing soccer, lower weights while exercising at the gym, more caution while doing the same sport as before), and others had no change (doing some kind of sports, playing musical instruments, gardening, and doing work outside the house). Nine patients had no problems in everyday life, three had minor problems, two had moderate problems, and one had severe problems mostly because he was not able to work as he did before the operation.

Literature Review

Various authors have reported their results with PRC for both arthritic and traumatic wrists. Imbriglia (5) reported improvement of the flexion-extension arc from 65 to 84 degrees postoperatively, average ulnar deviation 23 degrees, loss of radial deviation, and grip strength 80% (range 50–90%) of preoperative. Of 26 patients, three patients, all heavy manual workers, were unable to return to their previous occupation. At the follow-up 10 years after the operation, 12 patients developed signs of arthritic changes in the radiocapitate joint, and all were asymptomatic.

Another review of PRC (6) included 22 wrists with an average follow-up of 14 years. There were four failures requiring fusion at an average of 7 years. All four failures occurred in patients who were 35 years of age or less at the time of the operation. The remaining wrists had an average flexion-extension arc of 72 degrees, associated with an average grip strength of 91% of that on the contralateral side. The remaining 14 patients that did not experience failure were very satisfied. The patients rated nine wrists as not painful, four as mildly painful, five as moderately painful, and none as severely painful.

A retrospective study with a minimum 15-year follow up described long-term outcomes of PRC (7). Sixty-one patients who were operated on from 1967 to 1992 were included. All patients had wrist arthritis and underwent PRC. Average follow-up was 19.8 years. Postoperative range of motion and grip strength remained stable over time. X-ray revealed narrowing and arthritic changes in the radiocapitate joint. Most patients complained about wrist pain and took pain medication daily. Seventy-four percent of the patients were not satisfied with the results of their surgery. Twelve patients underwent wrist arthrodesis. Manual laborers with heavy demands were not able to return to their previous jobs. The authors recommended alternative treatments for patients with heavy demanding jobs and younger patients.

Wall et al. (8) reviewed the results of PRC in 17 wrists (16 patients) with a minimum follow-up of 20 years. Eleven wrists (65%) underwent no further surgery. The remaining six wrists underwent a second procedure, radiocarpal arthrodesis, and the average time to the second procedure was 11 years (range 8 months to 20 years). Ten of the 11 patients were satisfied after the operation, with a minimal decrease in motion and grip strength compared with the uninvolved side. The flexion-extension arc was 68°, and grip strength was 72% of the contralateral side. All patients returned to their original employment. There was no correlation between degenerative radiographic changes and satisfaction level. The predicted probability of failure revealed a higher risk in patients who underwent PRC at a younger age, which leveled off at age 40. The authors did not exclude younger patients from PRC in the future but suggested appropriate preoperative counseling.

Della Santa et al. (9) compared six patients with acute (up to 21 days after the injury) perilunate injuries and six patients with chronic conditions and an elective procedure. All twelve patients underwent PRC. Follow-up was 3 years. Patients with acute injuries were all satisfied with the results of the surgery, having 54% of the mobility of the contralateral hand and grip strength at 71% of the other hand. At follow-up, two patients developed radiocapitate degenerative changes (both also had a distal radius fracture at the time of the injury). In the elective group, half of the patients were not satisfied with the results, having mobility at 66% and strength at 59% of the other hand. Five patients developed degenerative changes in the radiocapitate joint.

Comparison of PRC and midcarpal arthrodesis for the treatment of SNAC and scapholunate advanced collapse (SLAC) in stage II (13) showed similar results after both procedures, with flexion/extension AROM postoperatively at 61 degrees in midcarpal arthrodesis and at 75 degrees in PRC. Pain relief was better in PRC, and higher grip strength was found in the midcarpal arthrodesis group. The rate of complications was similar in both groups.

Comparison of PRC and four-corner fusion for SLAC or SNAC wrist was performed in a systematic review of outcomes of 52 articles on this topic (14). More complications were shown after four-corner fusion (non-union, hardware issues, and dorsal impingement), whereas PRC provided a better postoperative range of movement but higher rate of subsequent osteoarthritis, the majority being asymptomatic. Grip strength, pain relief, and subjective outcomes were similar.

Authors report flexion-extension AROM being 68 to 84 degrees on operated wrists, or 63% of the contralateral side, with only one article describing it as being minimally decreased compared to the unoperated side. Measurements of AROM postoperatively showed 79 degrees of flexion-extension arc, on average 64% of the contralateral unoperated hand. Comparing only patients with preoperative and postoperative measurements of AROM, preoperative AROM was 76 degrees, and after operation it was 73 degrees. On average it was 97% of the preoperative AROM.

Grip strength also diminished in all studies, reaching 72 to 80% of the unoperated hand. Our research showed highly diminished strength in patients whose non-dominant hand was operated on, reaching 34% of the unoperated hand. The patient whose dominant hand was operated on had a grip strength of 82% of the unoperated hand. Postoperative grip strength was on average 77% of the preoperative value.

Comparing subjective feelings of the patients, three (13%) were dissatisfied with the results of the operation, two because of unemployment partly caused because of hand problems and one because he was not able to do everything he did before the operation in his everyday life. Eleven patients were very satisfied with the results (74%). Sixty percent of the patients had no problems in everyday life. There were no complications while treating these patients.

The main outcomes of the studies reviewed are shown in Table 5.

Conclusion

In our experience, PRC proved to be a good salvage procedure with high patient satisfaction after the procedure during a short follow-up time. Comparing operated and unoperated wrists might not be the best way to evaluate the success of the operation because most patients have chronic problems and diminished mobility and strength even before

Table 5. Articles review and comparison to our results. – = no data, AROM = active range of movement.

	Jebson (2003)	Stern (2005)	Berenger & Weiss (2004)	Della Santa (2010)	Ali (2012)	Wall (2013)	Celje General Hospital
Patients, *n*	18	21 (22 wrists)	26	12	61	16 (17 wrists)	15
Follow-up, years	13.1	14	–	3	19.8	20	1.7
AROM postoperatively, °	–	–	84	–	–	68	79
AROM (% of contralateral hand)	63	71	–	54–66	–	–	64%; 97% preoperative value
Grip strength (% of contralateral hand)	83	91	80% preoperative value	59–71	–	72	51%; 77% preoperative value
Secondary operations, *n*	2	4	–	0	12	6	0
Dissatisfied patients, *n*	1	–	–	3	74%	1	3

the operation. Also, there is significant difference in strength when comparing patients whose dominant versus non-dominant hands were operated on because the non-dominant hand likely has lower strength compared to the dominant hand in every person.

Comparing the status of the operated wrist before and after the operation shows a possibility of actually improving mobility and strength of the affected hand. With the low number of cases for which we were able to make this comparison, a larger study would be needed to confirm this.

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Laparoscopic Appendectomies at the University Medical Centre Ljubljana

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Abstract

Background. Acute appendicitis (AA) is the most common indication for emergency abdominal surgery. Laparoscopic appendectomy is the standard of care for the treatment of AA.

Methods. We performed a retrospective study of 1,153 patients with AA admitted to the Department of Abdominal Surgery, University Medical Centre Ljubljana, from January 1st, 2017 to December 31st, 2018. The following data were recorded: age, sex, duration of symptoms, type of treatment, duration of operation, operative outcomes, and postoperative complications.

Results. In the 2-year period we treated 1,153 patients with AA. There were 627 men (54.4%) and 526 (45.6%) women. The average age was 39.11 years. Abdominal ultrasound was the most common diagnostic procedure before surgery. In 1,079 (93.6%) patients, ultrasound was positive for AA. In 51 (4.4%) patients, AA was diagnosed with CT scan. During operation, AA without perforation was found in 897 (77.8%) patients. In 291 (18.9%) patients, the appendices were perforated. Perityphlitic abscess was found in 31 (2.6%) patients. In 1,111 (96.4%) patients, a laparoscopic appendectomy was performed. In 25 (2.2%) patients, the laparoscopic appendectomy was converted to open, and in six patients (0.5%) open surgery was performed. The average operative time was 39 minutes. The mean length of hospital stay was 4.91 days.

Conclusion. Laparoscopic appendectomy is a safe and effective method of treating AA. The advantages of laparoscopic appendectomy are shorter hospitalization and lower morbidity and mortality.

Introduction

Acute appendicitis (AA) is the most common abdominal surgical emergency, with around 50,000 to 300,000 acute appendectomies performed annually in the UK and the US, respectively (1). The lifetime risk is about 8%, but the pathogenesis is still not fully understood. It is thought to be multifactorial, with mechanical, infectious, and genetic circumstances leading to inflammation of the appendix (2). Acute appendicitis can present as simple or uncomplicated, with inflammation of the appendix, with or without phlegmonous imbibition of its surroundings, or as complicated AA, with inflammation having led to gangrene or perforation, with or without building of an abscess (2). Previous studies have estimated the prevalence of perforation at approximately 20%, higher rates being found in the elderly and young children, irrespective of sex (3, 4). AA rates initially decreased after the mid-20th century in the majority of the western world and have then stabilized since 1990 (5). Acute appendicitis is associated with significant morbidity, mortality, and costs to the healthcare system.

After clinical examination and blood tests, ultrasound is the recommended primary imaging strategy (2, 6). The reported sensitivities for ultrasound in experienced hands in detecting appendicitis are between 78% and 86% (7, 8). Although CT scan misses fewer cases, it exposes patients to radiation, is generally less available, and is associated with higher cost (6–8). It is primarily used as secondary imagining in patients with suspected AA at the University Medical Centre Ljubljana. Magnetic resonance is another emerging technique, especially in pregnant women and the pediatric population with suspected AA (9, 10).

The first diagnosis of AA and surgical removal of the appendix was performed in 1880 by Lawson Tait, and after that open appendectomy was the only standard treatment for AA for over a century, with only minor modifications of the surgical technique (11). Kurt Semm performed the first laparoscopic appendectomy in 1981 (12). In Slovenia, the first reports of laparoscopic appendectomy date to 1990. The method slowly gained ground in the 1990s and early 2000s, until it became the predominant technique and new gold standard in surgical treatment of acute and chronic appendicitis (11, 13). Multiple studies have demonstrated the superiority of laparoscopic appendectomy because it is associated with a lower rate of wound infections, less postoperative analgesia, and a shorter hospital stay (14–16). It also offers the possibility of inspecting the entire abdominal cavity and can determine other causes of abdominal pain mimicking AA (17). However, it is associated with a slightly longer operative time in comparison with traditional open appendectomy (15).

Recently published European trials have suggested that it is feasible to treat uncomplicated appendicitis nonoperatively with antibiotics alone (14, 15). Other studies have found that although non-operative management was associated with shorter hospital stays and fewer complications, the overall efficacy was lower because of the high rate of recurrence in comparison with appendectomy (16, 17). Therefore, laparoscopic appendectomy is still the most effective treatment for patients with AA (16).

Materials and Methods

We performed a retrospective study of 1,153 patients admitted to the Department of Abdominal Surgery, University Medical Centre Ljubljana from January 1st, 2017 to December 31st, 2018 who underwent an appendectomy. The final diagnosis was determined after receiving the results of the pathological examination.

From the database of our information system we collected data about patients' age, sex, preoperative diagnostic mode (ultrasound and/or CT scan), operative technique (laparoscopic appendectomy, open appendectomy, or explorative laparotomy and additional operative procedures), duration of operation, length of hospital stay, postoperative complications, and mortality. For all emergency surgeries we also analyzed the time until the surgery was performed.

Results

Altogether, 1,153 appendectomies were performed. There were 627 male patients (54.3%) and 526 (45.6%) female patients. The mean age of the patients was 39.11 years (37.28 years and 41.25 years for male and female patients, respectively) (Table 1).

Table 1. Patients' demographic data.

Parameter	Value
Total number of patients	1,153
Sex, *n* (%)	
• Male	627 (54.3%)
• Female	526 (45.6%)
Mean age (years)	39.11
Emergency operations, *n* (%)	1,132 (98.2%)
Diagnostic imaging, *n* (%)	
• Abdominal ultrasound	1,129 (97.9%)
• CT scan	24 (2.1%)
• CT scan after ultrasound	27 (2.5%)
• Diagnostic laparoscopy	18 (1.6%)

Abdominal ultrasound was used as primary diagnostic imaging in 1,129 (97.9%) patients and CT scan in 24 patients (2.1%). Diagnosis of AA was established with abdominal ultrasound in 1,079 patients (95.6%). In 27 (2.5%) patients, the abdominal ultrasound was negative and CT scan was used as secondary imaging afterward. In 18 (1.6%) patients after negative abdominal ultrasound, the decision for diagnostic laparoscopy and appendectomy was established with the clinical presentation.

Out of 1,153 appendectomies performed, 1,132 (98.2%) were performed as an emergency operation. Sixteen (1.4%) procedures were performed as elective procedures for the treatment of chronic appendicitis, and five procedures (0.4%) were performed either after unsuccessful drainage (four procedures 0.3%) or after unsuccessful conservative treatment (one procedure 0.1%) of AA (Table 2).

We analyzed the time between admission and the surgery. Only the 1,132 emergent appendectomies were included in the analysis. The average time was 5 hours and 28 minutes. Only 10 appendectomies (0.9%) were performed later than 24 hours, in two (0.2%) patients the abdominal ultrasound was negative, and in three (0.3%) patients only the control abdominal ultrasound was positive.

In 1,111 cases (96.4%) a laparoscopic appendectomy was performed. In 25 cases (2.1%) the laparoscopic approach was converted into the open approach, and in six cases (0.5%) a standard appendectomy was performed. There were 11 cases (1%) in which explorative laparotomy was used.

In 43 out of 1,111 (3.7%) patients with laparoscopic appendectomies, an additional procedure was performed during the appendectomy: in 13 (1.1%) patients cholecystectomy, in seven (0.6%) patients hernioplasty of the umbilical hernia, in five (0.04%) patients adhesiolysis, and in three (0.3%) patients extirpation of an ovarian cyst (Table 3).

Table 2. Type of operations.

Parameter (n = 1,153)	*n* (%)
Emergency appendectomy	1,132 (98.2%)
Elective procedure (chronic appendicitis)	16 (1.4%)
Appendectomy after unsuccessful drainage	4 (0.3%)
Appendectomy after conservative treatment	1 (0.1%)

Table 3. Operative technique.

Parameter (*n* = 1,153)	*n* (%)
Laparoscopic appendectomy	1,111 (96.4%)
Laparoscopy/conversion/open approach	25 (2.3%)
Open appendectomy	6 (0.5%)
Explorative laparotomy/appendectomy	11 (1.0%)

Table 4. Additional operations after conversion and open appendectomy.

Parameter (n = 25)	n (%)
Suture of the cecum	4 (16%)
Cholecystectomy	3 (12%)
Ileotransverse anastomosis	1 (4%)
Right-hemicolectomy	1 (4%)
Segmental resection of the small intestine	1 (4%)

Among 25 (2.3%) conversions, there were 14 cases (1.3%) in which an additional surgical procedure was performed: the cecum was sutured in four (0.4%) patients and a cholecystectomy was performed in three (0.3%) patients, in one (0.09%) patient an ileotransverse anastomosis was formed, in one (0.09%) patient a right-side hemicolectomy was performed, and in one (0.09%) patient a segmental resection of the small intestine was carried out (Table 4).

There were six open appendectomies, and in three (50%) patients an additional procedure was carried out; in all three (50%) patients it was a hernioplasty. Among 11 explorative laparotomies with appendectomies, five (45.5%) were performed with an additional procedure: in four (36.3%) patients surgical management of the ileus was carried out, and in one (9.0%) patient the tumor was extirpated.

We analyzed the average duration of an appendectomy performed. For 1,068 laparoscopic appendectomies, the average duration of the procedure was 39.7 ± 17.6 minutes.

Eighty-six out of 1,153 patients (7.4%) had complications. Sixteen (1.4%) patients required a reoperation. In three (0.26%) patients, surgical management of the postoperative ileus was required, in three (0.26%) patients evacuation of an intraabdominal abscess was required, and in three (0.26%) patients surgical hemostasis was required. In four (0.35%) patients, wound dehiscence was operated on (Table 5).

Sixty-nine out of 1,153 (5.9%) patients with complications were managed without surgical treatment. The most common complication was postoperative fluid formation in the abdomen; this occurred in 46 (3.9%) patients. Fifteen (1.3%) cases were managed with percutaneous drainage and 31 (2.7%) patients were managed conservatively. The second most common complication was the formation of an intraabdominal abscess in 10 (0.8%) patients. In two (0.17%) cases the abscess was evacuated with percutaneous drainage, and in eight (0.69%) patients it was managed conservatively. (Table 6)

Table 5. Surgical complications with reoperation.

Parameter (n = 16)	n (%)
Postoperative ileus	3 (18.7%)
Intraabdominal abscess	3 (18.7%)
Intraabdominal hemorrhage	3 (18.7%)
Wound dehiscence	4 (25.0%)
Relaparoscopy	2 (12.6%)
Suspected perforation	1 (6.3%)

Table 6. Surgical complications.

Parameter (n = 69)	n (%)
Postoperative fluid formation	46 (66.6%)
Percutaneous drainage	15 (21.7%)
Conservative treatment	31 (44.9%)
Intraabdominal abscess	10 (14.5%)
Percutaneous drainage	2 (2.9%)
Conservative treatment	8 (11.6%)
Postoperative ileus	3 (4.3%)
Wound infection	6 (8.7%)
Other complications	4 (5.9%)

Two out of 1,153 (0.017%) cases resulted in perioperative death. In both cases, the patients had comorbidities and the cause of death was cardiorespiratory arrest.

The final diagnosis was based on the pathologist's report. There were 1,030 patients with AA (89.3%). There were 62 cases (5.4%) of chronic appendicitis, 14 cases (1.2%) of fibrous obliteration, and 10 cases (0.9%) of hyperplasia of the lymphatic tissue. In 10 cases (0.9%), a normal appendix was found. In two cases (0.2%) the report was inconclusive.

There were 219 cases of perforation (19.0%), 31 cases of perityphlitic abscess (2.7%), and six cases of suspected perforation (0.5%). In 897 cases (77.8%) the appendix was not perforated.

In 10 cases (0.9%) a low-grade appendiceal neoplasm was diagnosed, and in seven cases (0.6%) it was a neuroendocrine tumor of the appendix. There were also two cases of a polyp and one case of adenoma. An adenocarcinoma was found in five cases (0.4%): two cases of appendiceal and one of each peritoneal, pancreatic, and cecal adenocarcinoma. There were 12 (1.9%) cases of negative appendectomies. (Table 7)

The average hospital stay was 4.91 days with a median of 4 days. It was significantly higher in patients with a perforated appendix (7.66 days with a median of 6 days) than in patients with a non-perforated appendix (4.12 days with a median of 3 days).

Discussion

Laparoscopic appendectomy has been a gold standard in the treatment of acute appendicitis at our institution for over a decade (13). It remains the most commonly performed emergency surgery, with 1,111 laparoscopic appendectomies in 2017 and 2018. The conversion rate was low, at 25 cases (2.2%), and it was commonly associated with the need for an additional procedure. When only a laparoscopic appendectomy was performed, the conversion rate was even lower, at 1.0% (11/1,068). A commonly reported conversion rate in the literature has been approximately 10% (22–24). Recently the conversion rate has been decreasing, with an American study reporting a conversion rate of 4.6% and an Italian study a conversion rate of 7.9% (25, 26).

Laparoscopic appendectomy has been associated with a lower rate of wound infection, less postoperative need for analgesia, a shorter duration of hospital stay, and the possibility of inspection of the entire abdominal cavity (14–17). It has been associated with a slightly longer operative time in comparison with traditional open appendectomy (15). In our study, the time required for the procedure was 39.7 ± 17.6 minutes. An Italian study reported an operative time of 54.9 ± 14.2 minutes, and in a Korean study it was 58.20 ± 20.72 minutes (27, 28). The last study is directly comparable to ours because it also included laparoscopic appendectomies that were performed by surgical

Table 7. Pathologist's report.

Parameter (*n* = 1,153)	*n* (%)
Acute appendicitis	1,030 (89.3%)
Acute appendicitis with perforation	219 (19.0%)
Chronic appendicitis	62 (5.4%)
Perityphlitic abscess	31 (2.7%)
Fibrous obliteration	14 (1.2%)
Hyperplasia of the lymphatic tissue	10 (0.87%)
Low-grade appendiceal neoplasm	10 (0.87%)
Neuroendocrine tumor of the appendix	7 (0.6%)
Adenocarcinoma	5 (0.43%)
Adenoma	3 (0.26%)
Normal appendix	12 (1.0%)

trainees, which was also the case in our analysis, although the extent of the influence on the operative time was not determined in our study.

The complication rate in our study was 7.4%, or 4.7% if laparoscopic appendectomies only were analyzed. Our data compare favorably with data from developed countries found in the international literature, in which the rate varies between 4 and 35.5% (29–32).

Greater inpatient delay before appendectomy has been associated with an increased risk of perforation (33, 34). In a recent meta-analysis, delaying appendectomy for up to 24 hours after admission does not appear to be a risk factor for complicated appendicitis, postoperative surgical-site infection, or morbidity, and it is considered an alternative to night-time surgeries (35). At our institution, over 99% of emergency appendectomies were performed within 24 hours of admission; the average in-hospital delay was 5 hours and 28 minutes.

The rate of perforation in our patient group was found to be 22.2% if suspected perforation and appendiceal abscess were included in the value. The rate of perforation is line with the rate that has been consistently reported in the literature in recent decades, which hovers around 20% (3, 4). The interpretation of the risk factors involved in perforation exceeds the range of this study. Other studies have identified age and pre- and in-hospital delay as the greatest contributors to the rate of perforation (3, 4, 36).

We use abdominal ultrasound as recommended primary diagnostic imaging when AA is suspected. We found abdominal ultrasound to be diagnostic in 95.6%, which shows a high degree of sensitivity. Other studies have reported a slightly lower rate of sensitivity, which varied between 86% and 78% (7, 8). With a high rate of sensitivity of abdominal ultrasound examination at our institution, we do not routinely use a CT scan as primary diagnostic imaging (6–8). Multiple studies have reported the sensitivity of a CT scan to be superior to an ultrasound examination, and therefore a CT scan is routinely used at our institution as the secondary imaging when a high degree of clinical suspicion has been established (37, 38).

The proportion of negative appendectomies was 1.0%. Worldwide, the rate of negative appendectomies has been steadily decreasing, from a historically acceptable 15 to 25% to 1.7% in a recent American study (39). However, given that the number of unusual pathological findings (i.e., other than acute or chronic appendicitis) was more significant, at 4.3%, most of the current literature continues to support routine histological examination of the tissue specimen (40, 41).

The average length of hospital stay was 4.91 days (median value 4 days) and was statistically significantly longer in the group with a perforated appendix (7.66 days with a median value of 6 days) than in the group with a non-perforated appendix (4.12 days with a median value of 3 days). A newer study has found that it is possible to discharge patients with uncomplicated appendicitis after 48 hours (42). Other studies have found that it is possible to discharge patients with uncomplicated appendicitis even sooner, after 24 hours without a significant difference in complications or readmission (43). In the United States, multiple institutions have initiated an outpatient laparoscopic appendectomy protocol with low morbidity and a low readmission rate (44, 45). Ambulatory appendectomies has been adopted in some European centers as well, but there is no consensus for selection of patients with AA for ambulatory surgery (46).

Conclusion

Laparoscopic appendectomy has become the standard treatment for AA. Open appendectomy or explorative laparotomy are performed in selected cases only. Rates of conversion and negative appendectomies are low and postoperative complications are uncommon, which reaffirms the safety of the procedure. In the future, the increasing age and number of polymorbid patients might pose challenges, and the adoption of ambulatory appendectomy at several centers might lead to further reduction in the average hospital stay.

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Treatment of Acute Diverticulitis at the Department of Abdominal and General Surgery, University Medical Center Maribor, during a 5-year Interval: A Retrospective Cohort Study

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Key words

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Research article

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Abstract

Background. Diverticulitis can present in about 10 to 25% of all patients with diverticulosis. It can be simple or complicated: associated with the formation of abscess, bowel obstruction, or perforation with peritonitis. With better understanding of the natural history of diverticulitis in recent years, there are increasing changes in treatment recommendations.

Methods. We performed a retrospective cohort study of all patients treated for acute diverticulitis at the Department of Abdominal and General Surgery, University Medical Centre Maribor, between January 1st, 2012 and January 1st, 2017. We were interested in the type of treatment (operative vs. conservative), surgical approach (resection with stoma vs. resection with primary anastomosis), and surgical technique (laparoscopic vs. open).

Results. During a 5-year interval we treated 92 patients with acute diverticulitis. Fifty-two patients were treated conservatively with antibiotics and 40 patients underwent urgent surgery. The most common procedure was the Hartmann operation, performed in 67% of our patients. A lavage and drainage of the abdominal cavity was performed in 17%, and a resection with primary anastomosis in 7%. In six cases we used a laparoscopic approach.

Conclusion. The majority of our patients with acute diverticulitis who were operated on were treated with reliable, tested procedures. Despite the encouraging results of primary anastomosis without stoma formation and laparoscopic techniques, there is not enough strong evidence to broadly recommend either technique. However, we strongly believe that further research and the results of ongoing randomized studies will prove that new modern techniques are feasible and safe.

Introduction

Diverticula are structural alterations within the colonic wall. They form from herniation of the colonic mucosa and submucosa through defects in the circular muscle layers within the colonic wall. This often occurs at sites of penetrating blood vessels in the colon (1). Diverticular disease is a gastrointestinal disease, defined as the presence of diverticula, and diverticulitis indicates the inflammation of a diverticulum or diverticula, which is commonly accompanied by gross or microscopic perforation (2). The overall prevalence of diverticulosis increases with age. Approximately 50% of individuals 60 and older will have diverticulosis, and by age 80 this percentage is expected to rise to approximately 70% (2).

Acute diverticulitis can present as mild intermittent discomfort or as chronic severe unrelenting abdominal pain. Systemic symptoms of fever and a change in bowel habits are common. Constipation is reported in approximately 50% of patients and diarrhea in 25 to 35%. Other symptoms include nausea, vomiting, and urinary symptoms (2). Diverticulitis can present in about 10 to 25% of patients with diverticulosis. It can be simple, without any associated complications, or complicated, associated with the formation of abscess, fistula, bowel obstruction, or frank perforation (3).

The most common classification of diverticulitis used today is Hinchey's classification, which was introduced in 1978 and has undergone several modifications (4–6). It has four stages (Table 1), and the stage alone is a significant predictive factor for a patient's mortality (7).

Nowadays, patients with generalized peritonitis due to complicated diverticulitis should undergo urgent operation. However, despite intensive research carried out during the last century, the best treatment algorithm is yet to be determined (8). There are multiple options that are linked to the gravity of clinical status, the patient's general condition, and the surgeon's preference.

Methods

We performed a retrospective cohort study of all patients treated for acute diverticulitis at the Department of Abdominal and General Surgery, University Medical Centre Maribor between January 1st, 2012 and January 1st, 2017. Basic data included age, sex, American Society of Anesthesiologists (ASA) status, and the type of treatment (conservative vs. operative). Operative and postoperative data included the type of operation, time until release, and postoperative complications, which were classified according to the Clavien–Dindo classification (9, 10). We were interested in the difference between the number of Hartman operations and operations with primary anastomosis and the share of laparoscopic procedures.

Results

During a 5-year interval we treated 92 patients with acute diverticulitis. There were 34 men and 58 women. The average age was 64 years (24–93). Most patients were ASA 2 (40%) and ASA 3 (36%).

Table 1. Hinchey classification of acute diverticulitis (4, 6).

Hinchey classification			Modified Hinchey classification	
Stage	Description		Stage	Description
I	Pericolic abscess or phlegmon		I	Pericolic abscess
II	Pelvic, intraabdominal, or retroperitoneal abscess		IIa	Distant abscess amendable to percutaneous drainage
III	Generalized purulent peritonitis		IIb	Complex abscess associated with fistula
IV	Generalized fecal peritonitis		III	Generalized purulent peritonitis
			IV	Fecal peritonitis

Table 2. Demography of the study population.

Variable	Category	Value
Age: years, mean ± SD		64.2 ± 14.8
Age: years, *n* (%)	< 50	15 (16.3)
	51–60	21 (22.8)
	> 60	56 (60.9)
Sex: *n* (%)	Male	34 (36.9)
	Female	58 (63.1)
ASA: *n* (%)	1	17 (23.6)
	2	29 (40.3)
	3	26 (36.1)

The distribution of patients admitted with acute diverticulitis according to the Hinchey classification is shown in Table 3.

Fifty-two patients were treated conservatively with antibiotics and 40 patients were urgently operated on. The type of treatment according to the Hinchey classification is shown in Table 4.

Median hospitalization time in the conservative group was 7 days and in the operative group 14 days. The most common procedure was the Hartman operation, performed in 67% of our patients. In 17% we performed lavage and drainage, and in 7% a resection with primary anastomosis. We performed six laparoscopic procedures.

Discussion

Diverticulosis is fairly common condition in western countries. It is the fourth most expensive gastrointestinal condition in the developed world (9). According to the literature, there should be no clear predisposition to diverticulosis on the basis of sex (10), and so it is interesting that in our study the rate of females admitted for acute diverticulitis is much higher than that of males. On the other hand, a large Canadian epidemiologic study observing a 14-year interval found that admission rates were higher for women than for men in nearly all age groups. The difference rose from

Table 3. Number of patients admitted per year according to the Hinchey classification.

Hinchey classification	Year					Total
	2012	2013	2014	2015	2016	
1	9	7	14	5	12	47
2	1	6	7	4	5	23
3	4	2	4	6	1	17
4	2	0	0	2	1	5
(Total)	**16**	**15**	**25**	**17**	**19**	**92**

Table 4. Type of treatment according to the Hinchey classification. AB = antibiotic, HA = Hartmann procedure, Lap lav + drain = laparoscopic lavage and drainage, Lav + drain = lavage and drainage, PA = resection with primary anastomosis.

Hinchey classification	AB	HA	Lap lav + drain	Lav + drain	PA	Other
1	47	0	0	0	0	0
2	5	7	5	1	3	2
3	0	15	1	0	0	1
4	0	5	0	0	0	0
(Total)	**52**	**27**	**6**	**1**	**3**	**3**

15/100,000 in the 40–49 age group to 137/100,000 in the 80 and older age group (11). Researchers have tried to explain these discrepancies between men and women by the specific protective effect of testosterone on the colonic wall from weakening with age in men (12), and by the possible negative effect of pregnancy on the wall of the colon due to high pelvic pressures that occur during gravidity and labor in women (13).

The surgical treatment of acute diverticulitis with complications has progressed over the years. A three-stage procedure made way to a two-stage procedure, the so-called Hartman procedure, in the 1980s (14). It refers to sigmoid resection with end colostomy with later reversal. It is associated with high morbidity and mortality, but there is also the problem of non-reversal of colostomies (15). Surgery has therefore evolved to a one-stage procedure in which resection and primary anastomosis is performed in a single procedure, although anastomosis is sometimes constructed in the presence of perforation or peritonitis (14). Many studies demonstrated no differences between the Hartmann procedure and primary resection with anastomosis in terms of morbidity and mortality (15, 16). In our study, the majority of patients (more than 58%) underwent Hartman's two-stage procedure. There were only four primary resections with anastomosis, all in the Hinchey 1 and 2 patient group, and all were operated on in the last year of our period investigated.

With the rise of laparoscopic surgery, new challenges and techniques have appeared. Laparoscopic peritoneal lavage has emerged as a promising alternative to sigmoidectomy in patients with purulent peritonitis owing to perforated diverticulitis (17). This technique was first described in 1996 and the results were very encouraging. Many laparoscopic surgeons used this technique with good results, and the strategy was even recommended by certain national boards (18). Unfortunately, in a large multicenter, parallel-group, randomized, open-label study the trial had to be stopped because of the high morbidity and mortality rate in the lavage group, and it was concluded that laparoscopic lavage is not superior to sigmoidectomy for the treatment of purulent perforated diverticulitis (17). Current recommendations are that there is not enough evidence to recommend laparoscopic lavage as an alternative to bowel resection (14), and even the authors who concluded in their studies that laparoscopic lavage for perforated diverticulitis with purulent peritonitis (Hinchey 3) is feasible and safe have voiced warnings before widespread implementation of this technique (19).

According to our data, we performed six laparoscopic peritoneal lavages with drainage. There was one patient with Hinchey 3 diverticulitis, but all the others had Hinchey 2 grade. All laparoscopically treated patients had no postoperative complications and were on average dismissed on postoperative day 9, 5 days earlier than average.

Conclusion

The treatment strategy for acute diverticulitis is still evolving. Modern practice guidelines are adapted to individual cases, considering disease severity, risk factors, persistency of symptoms, and the patient's wishes. The choice of surgical approach is left to the discretion of the surgeon. At our department, the majority of patients were still treated with reliable, tested procedures, but we have also started using new promising techniques.

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Laparoscopic–Endoscopic Cooperative Surgery for a Non-Ampullary Duodenal Neuroendocrine Tumor after Incomplete Endoscopic Resection

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Key words

non-ampullary duodenal NET, laparoscopy, endoscopy

Case Report

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Abstract

Much controversy exists in the treatment of small low-grade and endoscopically incompletely resected non-ampullary duodenal neuroendocrine tumors (NET). In recent years, the development of minimally invasive surgery has spawned a less aggressive treatment option for these patients. We present the case of a 21-year-old patient who was incidentally diagnosed with a duodenal NET and was treated with laparoscopic–endoscopic cooperative salvage surgery after incomplete endoscopic NET resection. He was admitted to our hospital for further evaluation and treatment after incomplete endoscopic resection of a NET in the third portion of the duodenum. The histological examination revealed a moderately differentiated NET with 20 mitoses on 10 high-power fields and a Ki-67 of 3 to 20%. The tumor involved the resection margin. The patient was scheduled for a laparoscopic–endoscopic cooperative full-thickness excision of the tumor remnant. The histological analysis of the surgical specimen revealed fibrotic tissue after previous endoscopic mucosal resection with no residual tumor cells. The patient was discharged on the 5th postoperative day. With this case presentation we wish to show that, in experienced hands, the minimally invasive approach is a treatment alternative with excellent long-term functional results, reducing the trauma of open surgery and high patient morbidity. We therefore believe that in the future laparoscopic–endoscopic cooperative surgery will firmly be established as the treatment of choice for small low-grade and incompletely resected NETs of the non-ampullary duodenum.

Introduction

Although the incidence of duodenal neuroendocrine tumors (NET) has been slowly rising due to better imaging modalities and wider use of endoscopy, the experience in dealing with these tumors is relatively small (1–6). The duodenal NETs are classified as ampullary or non-ampullary due to their different biological behavior (1). Ampullary duodenal NETs are generally more aggressive, and so the choice of the treatment modality is relatively straightforward. In most cases, a cephalic pancreaticoduodenectomy is advocated (1, 3). Non-ampullary duodenal NETs, however, can behave relatively indolently and the choice for their treatment depends on the size of the tumor.

The latest European Neuroendocrine Tumor Society (ENETS) guidelines recommend surgical resection for non-ampullary duodenal NETs larger than 20 mm, whereas non-ampullary duodenal NETs smaller than 10 mm without lymph node involvement and confined to the submucosal layer should be resected endoscopically. Much more controversy exists for non-ampullary tumors smaller than 20 mm. In addition, the choice of a salvage treatment after incomplete endoscopic resection of small non-ampullary NETs is also a matter of debate.

Because of the small incidence of duodenal NETs, it is relatively difficult to obtain enough experience for endoscopically borderline resectable or endoscopically unresectable duodenal NETs. Given the relatively indolent behavior of these tumors, it seems that open surgery in these cases presents overtreatment for these patients and exposes them to a highly morbid procedure. In recent years, the development of minimally invasive surgery has spawned a third and less aggressive treatment option for patients with small non-ampullary duodenal NETs. We present the case of a 21-year-old patient who was incidentally diagnosed with a duodenal NET and was treated with laparoscopic–endoscopic cooperative salvage surgery after incomplete endoscopic NET resection.

Case Presentation

A 21-year-old man was admitted to our hospital for further evaluation and treatment after incomplete endoscopic resection of a duodenal NET. His previous medical history was uneventful apart from dyspeptic pain in the epigastrium and reflux that he had been suffering for 6 months before hospitalization. He was admitted to another hospital for endoscopic evaluation of the dyspeptic problems. An esophagogastroduodenoscopy was performed, which disclosed multiple superficial erosions in the esophagus and a small hiatal hernia. The endoscopy was carried out to the second portion of the duodenum, where a 7 mm flat and broad-based polyp on the lateral wall was found. A polypectomy was performed with endoscopic mucosal resection, and the specimen was sent for histology. The histological results confirmed that the resected polyp was a duodenal NET with moderately differentiated cells with 2 to 20 mitoses on 10 fields of high magnification and a Ki-67 of 3 to 20%. The radial resection borders were free of tumor cells, but the tumor extended to the base of the specimen, suggesting a R1 resection. The patient was sent for an Octreoscan and a SPECT/CT with negative results, excluding possible multifocal disease or distant metastases. The patient was then transferred to our hospital for further treatment. The site of the scar was marked with a carbon dye before the operation. His medical records had been reevaluated and we decided to perform laparoscopic–endoscopic cooperative reresection of the excisional scar. The procedure was discussed with the patient, and he agreed to the operation. During the operation the identification of the scar was facilitated with endoscopic transillumination. The resected specimen was sent for definite histology, the defect was closed with a running suture, and a drain was placed behind the duodenum. After the procedure, the patient was admitted for observation to our intensive care unit for 2 days. On the 1st postoperative day the nasogastric tube was removed, and the patient began with slow sips of fluid. On the 2nd postoperative day enteral feeding was increased to 100 ml fluids per day, and the patient was transferred to the ward. On postoperative day 2 the patient started to pass stool, and we began to slowly increase enteral feeding until postoperative day 5, when the patient was allowed to ingest solid food. The abdominal drain was removed and oral analgesics were started. After an uneventful recovery, the patient was discharged on postoperative day 6. The histological analysis of the surgical specimen revealed fibrotic tissue and intramural bleeding after polypectomy with no sign of residual NET. At the last follow-up 6 months after the operation (Figure 1), the patient was well with no functional disturbances and no signs of disease recurrence.

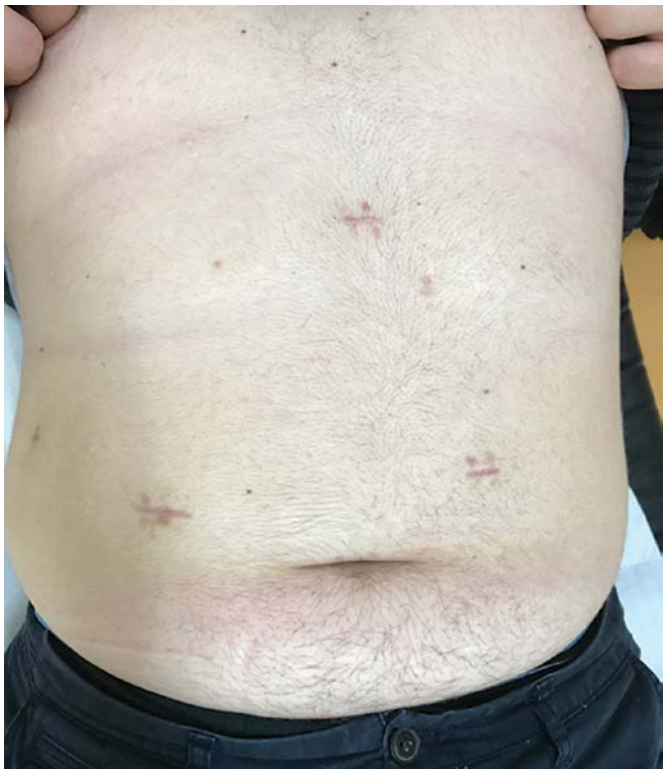

Figure 1. Abdominal incision scars 6 months after operation.

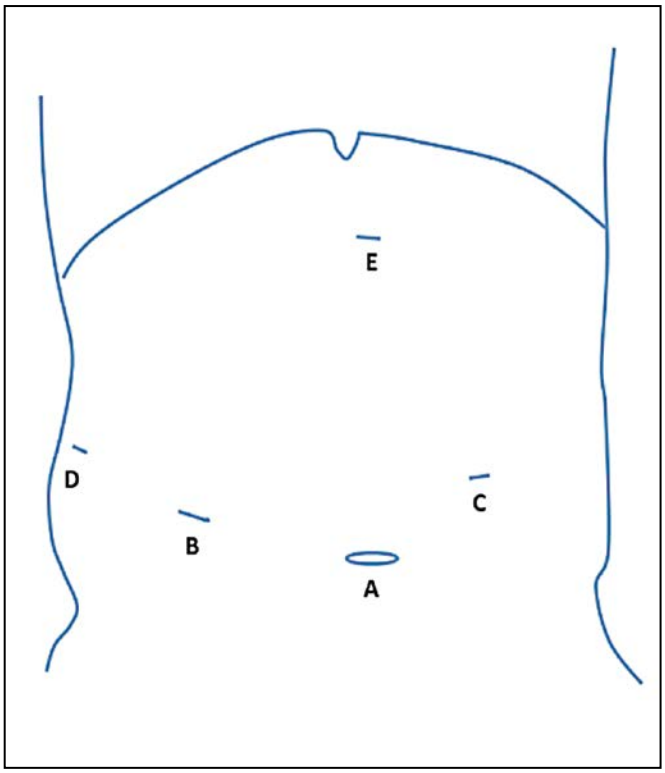

Figure 2. Trocar placement.

Surgical Procedure

The patient was placed in prone position with his legs abducted. After preparation of the surgical field and draping, a small incision was placed supraumbilically and pneumoperitoneum was established with a Veress needle. A 12 mm trocar was placed supraumbilically, after which a 12 mm trocar was placed under laparoscopic control in the middle clavicular line and a 5 mm trocar in the anterior axillar line. In addition, one 10 mm trocar was placed in the epigastrium for liver retraction and a 5 mm trocar in the mesogastrium (Figure 2). The surgeon was positioned between the legs with the first assistant on the patient's right and the second assistant on the patient's left. After exploration of the abdominal cavity, the hepatocolic ligament was incised and the hepatic flexure of the colon was mobilized caudally until the prerenal fascia was visible. The preparation continued toward the left. When the second portion of the duodenum was well visible, we began with Kocherization of the duodenum. Kocherization was carried out from right to left, with the ultrasonic scalpel held in the surgeon's left hand while the right hand retracted the duodenum with non-traumatic forceps toward the patient's left side. The second assistant continuously exerted traction on the transverse colon toward the left, while the first assistant retracted the hepatic flexure caudally. The Kocherization was continued until the second and the third portion of the duodenum were completely mobilized from the inferior vena cava. As the final step, the third portion of the duodenum was mobilized from the transverse mesocolon. After the duodenum was freed from the retroperitoneum, an intraoperative duodenoscopy was performed. The tumor site was clearly visible with the transillumination of the spotted tumor site with the endoscope. The site was marked with a 2-0 holding suture under endoscopic supervision. The site was completely excised with an ultrasonic endoscalpel and placed in an endobasket. The defect was closed with two 3-0 resorbable running sutures. After the suturing, the duodenum was tested for leakage with gentle endoscopic insufflation. A 15 French drain was placed behind the duodenum and the specimen was extracted through the supraumbilical incision. The duration of the operation was 260 min (Figure 3).

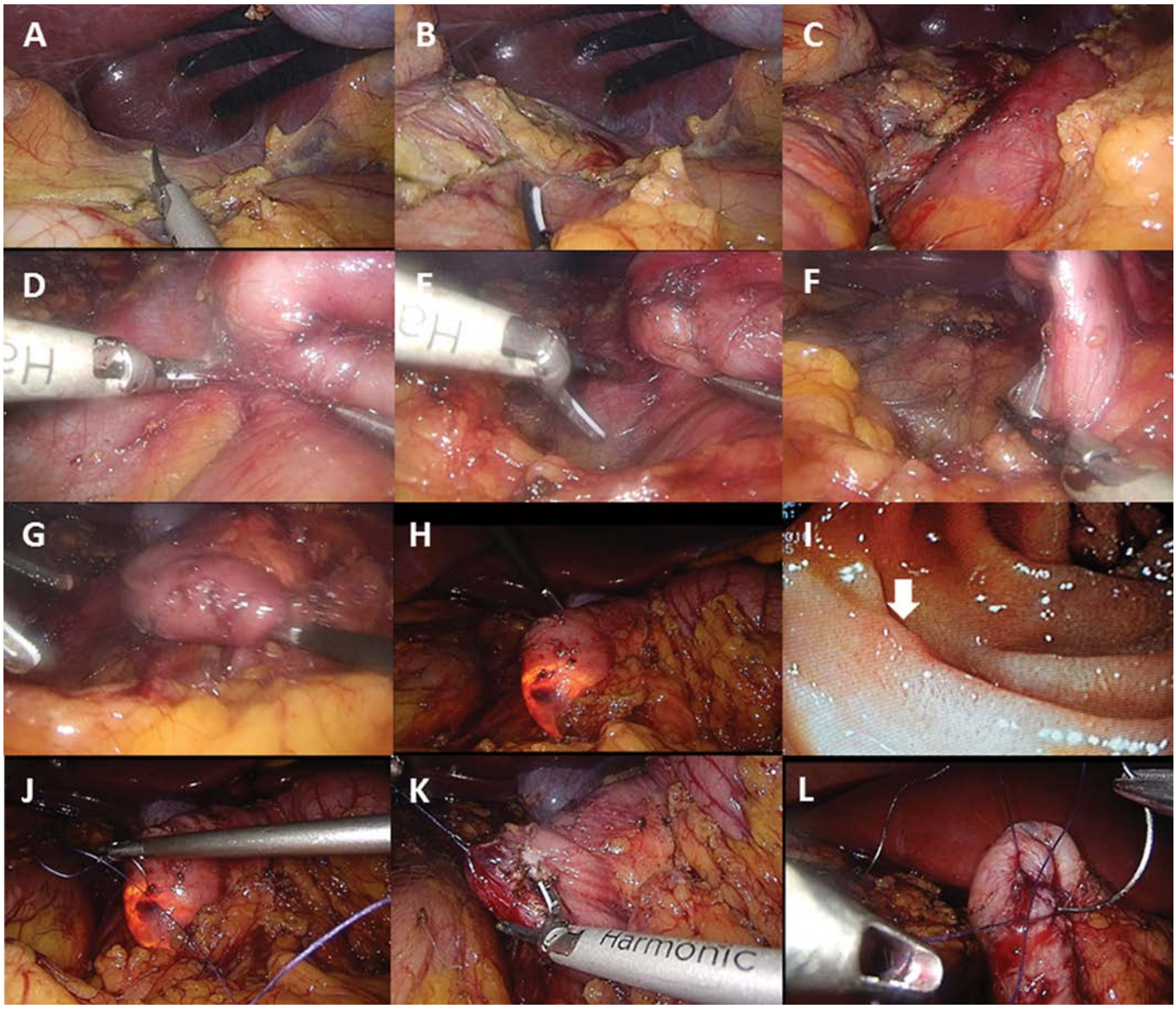

Figure 3. Intraoperative pictures of the laparoscopic–endoscopic cooperative full-thickness duodenal wall excision. A = mobilization of the hepatic flexure caudally; B = incision of the prerenal fascia; C = Kocherization of the second part of the duodenum; D = mobilization of the duodenum and the head of the pancreas from the inferior vena cava toward the left; E, F = mobilization of the third part of the duodenum from the transverse mesocolon; G = the third part of the duodenum is completely mobilized and lifted anteriorly with the grasping forceps; H = intraoperative duodenoscopy, the carbon dye spot is clearly visible; I = endoscopic view of the scar after neuroendocrine tumor excision, the white arrow marks the scar, the reddish discolored mucosa of the scar is clearly visible; J = laparoscopic holding suture placement under duodenoscopic surveillance; K = excision of the tumor with ultrasonic scalpel; L = laparoscopic suturing of the duodenal wall defect.

Discussion

In recent years, a slow increase in the incidence of duodenal NETs has been noted (1–5, 15). This rise has been attributed to more widespread use of endoscopy, and therefore clinicians more often face difficult decision on how to treat these relatively indolent tumors. The treatment for small and low-malignant NETs and incompletely excised NETs of the duodenum, however, is still highly debatable. For ampullary NETs, the latest ENETS guidelines propose surgical resection (1, 3). For non-ampullary NETs, the decision is much more

difficult. Neuroendocrine tumors larger than 20 mm should be resected because of the high probability of lymph node metastases. Neuroendocrine tumors smaller than 10 mm can be treated with endoscopy, but the case is not so clear for NETs ranging from 10 mm to 20 mm and those not resectable with endoscopy. In cases of unsuccessful treatment, the only option has traditionally been open surgery, which potentially exposes patients with an indolent lesion to harmful complications and long-term functional disabilities (2, 7–10). This article presents the case of a 21-year-old man with an incomplete NET excision of the third portion of the non-ampullary duodenum.

Small NETs of the non-ampullary region of the duodenum have a small probability of lymph node metastases (1, 3, 11). Given their accessibility with endoscopy, they should ideally be treated with endoscopic mucosal or endoscopic submucosal resection. However, in contrast to the stomach, where the organ walls are thick and the working place is large, the duodenum poses specific difficulties. Because of the thin duodenal wall, endoscopic resections have a high risk of complications, occurring in 30% and with early and late perforation described as the most dangerous (2, 7–10). Once a perforation has occurred, it can rarely be controlled endoscopically, and the patient must be operated on and further subjected to intensive care because of severe peritonitis and sepsis. Another problem is the narrow working space in the duodenum, which makes endoscopic maneuvering and the resection difficult (2, 7–10). The technically challenging procedure and narrow working space often result in insufficient resections, necessitating further surgical treatment. The development of laparoscopy has allowed avoidance of an open surgical procedure in patients with low-malignant or endoscopically unresectable NETs.

Laparoscopy allows better visualization of the duodenum and reduces the risks of early and late perforations common to endoscopic mucosal and submucosal resections in the duodenum. The defect can be closed up safely with suturing of the entire wall. If the tumors are located on the anterior wall of the second part of the duodenum, the excision is straightforward. However, tumors in every other region are inaccessible without mobilization of the duodenum. Laparoscopic Kocherization takes considerable laparoscopic skills. Additionally, suturing of the wall defect after the excision of the lateral or posterior duodenal wall can be exceedingly difficult. Excision of the tumor with sufficiently clear resection margins remains a great challenge. The tumor is often not clearly visible even if the site has been preoperatively marked with carbon dye. Furthermore, the resection margins cannot be safely determined intraoperatively.

To deal with these difficulties, laparoscopically assisted duodenal excision was proposed by Abe et al. (10). With this approach, the surgeon mobilizes the duodenum laparoscopically so it can be lifted toward a small midline laparotomy. The procedure is than carried out with an open approach. Some proponents of laparoscopically assisted surgery claim that this type of surgery offers significant advantages over total laparoscopic full-thickness excisions of the duodenal wall because extracorporeal suturing eliminates the risk of postoperative hemorrhage, anastomotic insufficiency, surgical site infection, and duodenal deformity (10). However, mobilization of the duodenum toward the laparotomy, as proposed by Abe et al., could prove very difficult or even impossible in obese patients. This approach is therefore limited to lean patients with the tumor located in the second portion of the duodenum. In our case, the tumor was located on the lateral wall of the third part of the duodenum, and so the laparoscopically assisted approach would probably be unsuccessful. We therefore decided to perform laparoscopic–endoscopic cooperative surgery.

This type of surgery was first described by Hiki et al. and was developed to overcome the drawbacks of the laparoscopically assisted procedures (12). In laparoscopic–endoscopic cooperative surgery, the duodenum is Kocherized laparoscopically, but then the tumor site is marked or even excised intraoperatively endoscopically. Moreover, full-thickness wall excisions can be performed laparoscopically under endoscopic view. The defect can be safely sutured, preventing leakage after endoscopic excisions. In our case, laparoscopic–endoscopic cooperative surgery was performed. We also performed a full-thickness wall excision because endoscopic excision had already been previously performed in our patient. The tumor was located on the lateral wall on the D3 portion in our patient and was safely extracted. This location would have been relatively inaccessible if a laparoscopically assisted procedure had been performed with the duodenum mobilized to the level of laparotomy. Totally laparoscopic–endoscopic full-thickness excision has the advantage

that it can safely be performed in obese patients because mobilization to the level of laparotomy can be avoided.

Opponents of the total laparoscopic approach claim that laparoscopic suturing in this region is prone to leakage. Our patient, however, did not have any leakage, and furthermore reports from experienced centers support the safety of laparoscopic suturing with extremely low morbidity (2). Abe et al. claim that with laparoscopic full-thickness excision of the duodenal wall, there is a significant risk of intraperitoneal seeding (10). Duodenal NETs smaller than 20 mm are very indolent in their behavior, and therefore the risk of seeding is negligible (13). Moreover, none of the authors that presented their long-term experience with full-thickness excision of low-grade duodenal NETs have reported intraabdominal recurrences due to intraoperative seeding (13). Therefore, we feel that seeding of low-grade tumors after R0 full-thickness excision is exceedingly rare because no intraabdominal implants after full-thickness excisions have ever been recorded in previous reports (6, 14). In addition, the incidence of lymph node metastases in small low-grade gastrointestinal NETs, which would necessitate a more aggressive surgical approach, are reported to range from 7% to 15% (1, 3, 11, 14). Due to the low rate of lymph node metastases and low recurrence rates of low-grade duodenal NETs, we are convinced that full-thickness excision does not predispose patients to locoregional recurrences and is sufficient for small low-grade and incompletely resectable NETs of the non-ampullary duodenum. At the last follow-up 6 months after surgery, our patient was free from disease, further supporting the safety of laparoscopic–endoscopic coordinated full-thickness excision.

The case of laparoscopic–endoscopic coordinated non-ampullary duodenal NET excision presented in this article is an example of a minimally invasive approach for the treatment of low-malignant or endoscopically unresectable NETs of the duodenum. We showed that in experienced hands the trauma caused by open surgery for these indolent tumors can be reduced without exposing patients to higher morbidity, providing excellent long-term functional results. Therefore, we believe that in the future laparoscopic–endoscopic cooperative surgery will firmly be established as the treatment of choice for small low-malignant and incompletely excised NETs of the non-ampullary duodenum.

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Soft Tissue Coverage of a Heel Skin Defect in a Pediatric Patient

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Key words

skin defect, dermal matrix, child, traumatic wound, case report

Case Report

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Abstract

A reconstruction ladder is used to decide how to treat a variety of skin defects. Often it is good to have alternative possibilities, such as a dermal matrix. This case report presents the case of a 4-year-old boy who suffered an injury to his right leg. Despite appropriate primary surgical treatment, the infection caused a skin defect with an exposed calcaneus bone. The wound was covered with a dermal matrix and later with a split-thickness skin graft. The aesthetic and functional outcomes of the treatment were satisfactory.

Introduction

Wounds with exposed deeper tissues impossible to suture have always been a challenge in reconstructive surgery. In deciding how to close large skin defects, reconstructive surgeons follow a so-called reconstruction ladder. This is applied to cases ranging from primary surgical treatment with direct suturing of wounds and skin grafts to more complex flaps, both local and free.

Traumatic skin defects arise in both adults and children. Initially, microsurgery for children was questionable due to the small diameter of the blood vessels. With the advance of microsurgical techniques, the use of free flaps is now successful in children as well as in adults (1, 2), but the procedure remains demanding for the patient and the medical personnel involved (3). Initially, the minimum blood vessel diameter required for safe anastomosis was 0.7 mm; however, the use of super-microsurgical techniques makes possible anastomosis of perforating vessels of smaller diameters (1). In children, compared to the adults, associated diseases (diabetes, arterial hypertension, atherosclerosis, and venous insufficiency) are rare, and therefore these cases involve fewer risk factors that could endanger survival of the flap (4).

The closure of defects in the ankle and foot is particularly difficult because the bone or tendons are often exposed. The lack of soft tissue in this area and additional trauma to the limb limit the use of local flaps (5).

Free flaps, such as an anterolateral thigh flap (ALT) or circumflex iliac artery perforator flap (SCIP), can be used (1, 4). Based on our experience, the use of free flaps in this area does not provide satisfactory outcomes because the flap is thick and lifted above the skin surrounding the defect. This makes wearing footwear more difficult and, consequently, additional procedures are required to improve functionality.

With the emergence of dermal matrix in 1981, a new method of defect closures appeared as an alternative to the existing reconstructive ladder (6). Dermal matrix is a regeneration system consisting of two layers. The porous matrix layer consists of bovine collagen fibers and glucosamine. This layer serves as a basis for the migration of fibroblasts, macrophages, lymphocytes, and capillaries from the defect and allows the formation of neodermis, which is histologically very close to normal human dermis. The second layer is temporary and consists of silicone, which acts as a protection against the external environment (7, 8).

Complications that arise with the use of the dermal matrix are infections and the formation of hematoma under the dermal matrix. These can be avoided with appropriate changes of dressings and efficient hemostasis prior to dermal matrix application (8).

The vascularization of the dermal matrix evolves from granulation tissue in and around the defect and spreads over nonvascular tissue (bones and tendons). The silicon layer of dermal matrix prevents tissue dehydration and maintains a suitable environment for tendons and bones to remain vital. The transparent color of the silicon layer allows inspection of the defect, which is important for assessing the development of infection or occurrence of a hematoma. The dermal matrix must be firmly attached to the defect. In this way, shear forces that might tear the newly formed vessels do not occur (9).

The healing process can be optimized with the use of negative pressure. The system for creating negative pressure consists of polyurethane foam connected to a sub-atmospheric pressure of 50–125 mmHg. By continuously removing the secretion from the wound, this minimizes the risk of developing edema, prevents infection, reduces the possibility of hematoma occurrence, and optimizes the adherence between the wound and the graft or matrix. With the use of a negative pressure system, there is less danger of infection, and so waiting for complete vascularization of the dermal matrix over the exposed tissues may be prolonged (9).

At first, dermal matrix was used to cover major burns and, in children, to cover a defect after the removal of congenital nevi and in reconstructing congenital abnormalities (10–14). The use of dermal matrix to cover skin defects after trauma, where due to various reasons the use of grafts and flaps is impossible or undesirable, is becoming more frequent (8).

The main disadvantages of the use of dermal matrix are the price of the matrix and materials used, and prolonged treatment (13). Dermal matrix is relatively expensive, and treatment requires two surgeries. In the first procedure, the dermal matrix is attached to the defect. After 2 to 3 weeks, when the dermal matrix is completely vascularized, which can be macroscopically detected in the change of color from yellow to red, the silicon layer begins to peel off. At this point, the silicon layer must be removed and a split-thickness skin graft must be attached to the vascularized matrix. It takes an additional week for a split-thickness skin graft to heal (7).

The use of dermal matrix provides functionally and aesthetically satisfactory outcomes. Compared to skin grafts, the advantage of dermal matrix is the elasticity of the coverage. The dermal matrix is thin; it does not create an additional volume in areas with less subcutaneous tissue, and it prevents the need for secondary tissue-thinning surgery (6).

Here we present a case of a 4-year-old boy who suffered an injury in the area of the right calcaneus. The wound was first covered with a dermal matrix and later with a split-thickness skin graft. The outcome was satisfactory.

Case Presentation

A 4-year-old boy came to the hospital because his right foot had been caught in bicycle spokes. He suffered an injury to the area of the right calcaneus. At admission to the hospital, an extensive tissue laceration was visible – a V-shape wound with a diameter of 12 cm stretching over the bone. Under general anesthesia, primary surgical treatment of the wound was performed. The skin was

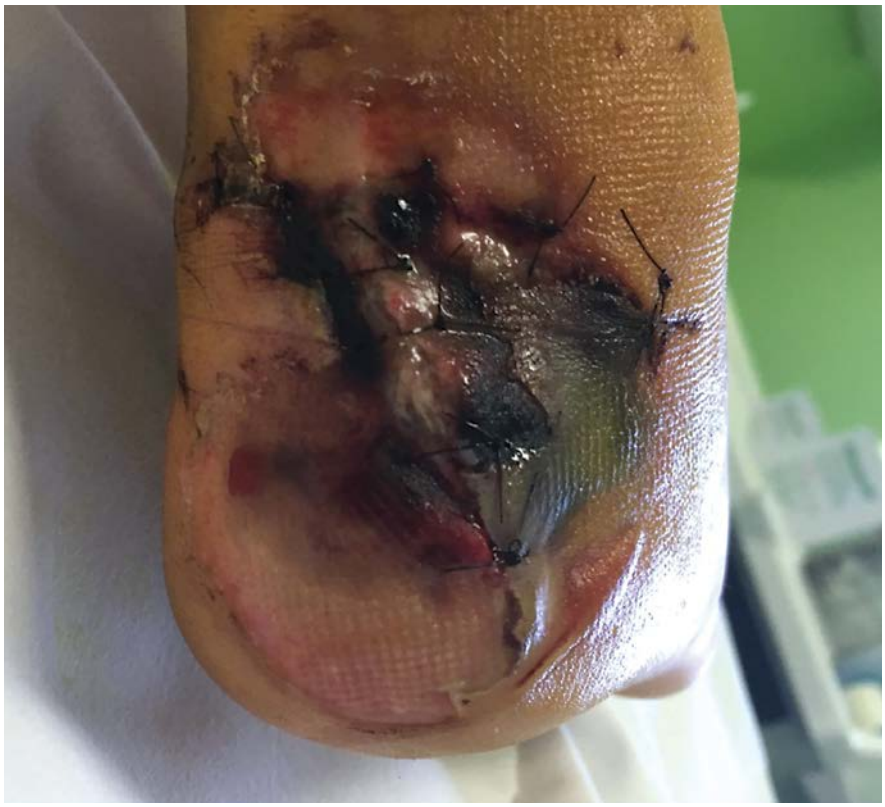

Figure 1. Necrotic flap after primary treatment with direct suturing.

cleaned with antiseptics, the wound was irrigated with saline, surgical debridement and hemostasis were performed, and the wound was directly sutured. After the surgical procedure, the boy was admitted to the children's surgery department.

On the 2nd day after the injury, necrosis of the traumatic flap was visible, and a plastic surgeon was consulted. The boy had a fever and elevated inflammatory parameters, and fluid was oozing from the wound.

On the 3rd day, the boy underwent another surgery. This operation included excision of the necrotic traumatic flap and the necrotic surrounding tissue. Tissue cultures were taken from the wound. The wound was rinsed and a wet dressing was applied. Amoxicillin / clavulanic acid was introduced into the therapy. Dressings were changed every 6 hours. Microbiology results indicated the presence of *Staphylococcus hominis* (low number), *Clostridium perfringens*, and *Prevotella* spp. Following the advice of an infectious disease specialist, the antibiotic clindamycin was introduced. According to the antibiogram, the two antibiotics were sufficient to treat the bacterial infection.

With regular changing of the dressings, the secretion from the wound diminished and red discoloration of the wound edges disappeared. Negative pressure therapy was initiated. Granulation tissue started forming around the edges of the wound; a defect over the calcaneal bone and Achilles tendon remained (Figure 2).

With the clearing of the inflammation, we decided to cover the exposed subcutaneous tissue. After exploring various options for reconstruction, a dermal matrix with silicon cover was chosen to cover the exposed structures. Another operation was performed. The wound was debrided, and dermal matrix was applied over the exposed bone and tendon. Microbiology tests of the tissue collected intraoperatively indicated the presence of cutaneous flora in the wound. After the procedure, the boy's foot was bandaged. The day after the procedure, the condition of the dermal matrix was assessed. There was no hematoma present under the dermal matrix; a system for a negative pressure therapy was applied. At the next change of the dressing, there were no signs of infection and there was no fluid collection under the dermal matrix. The patient was discharged to outpatient care while he continued receiving amoxicillin / clavulanic acid. A month after application of the dermal matrix, vascularization was nearly complete, with 1 cm^2 of non-vascularized area in

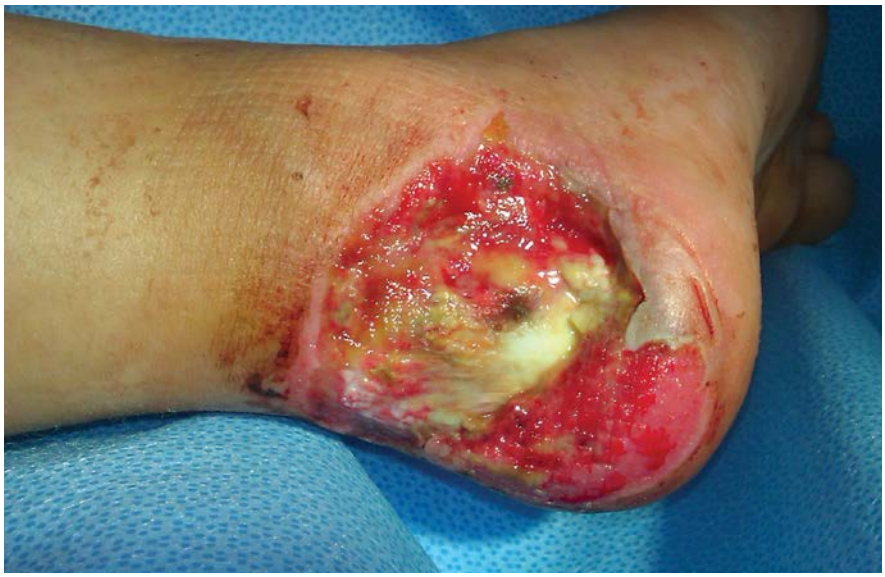

Figure 2. Red discoloration of the edges with granulation tissue. A defect over the calcaneal bone and Achilles tendon remained.

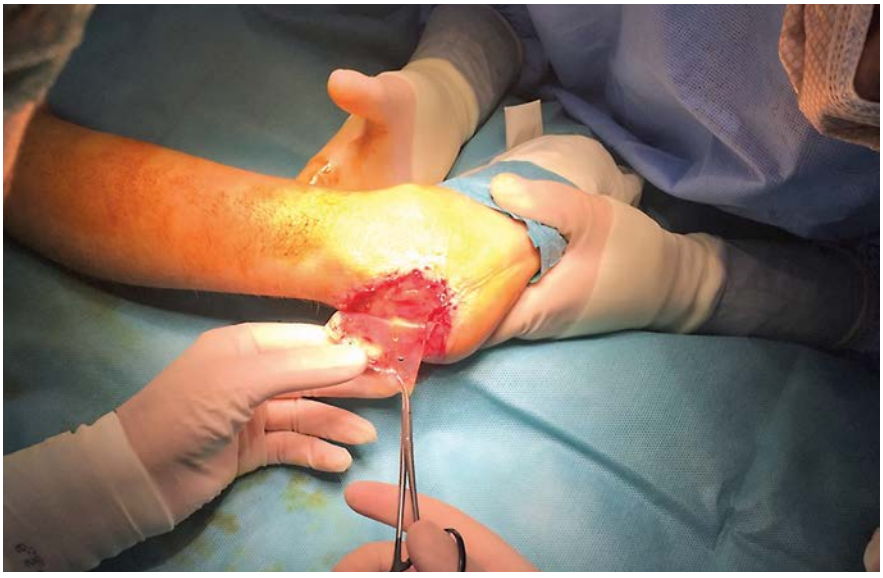

Figure 3. Removing the silicone layer

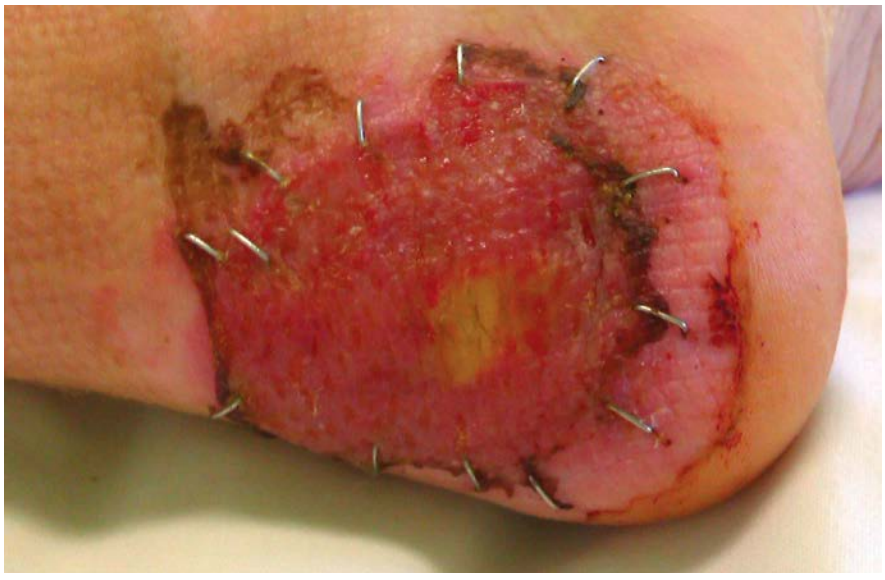

Figure 4. Split-thickness skin graft covering the defect.

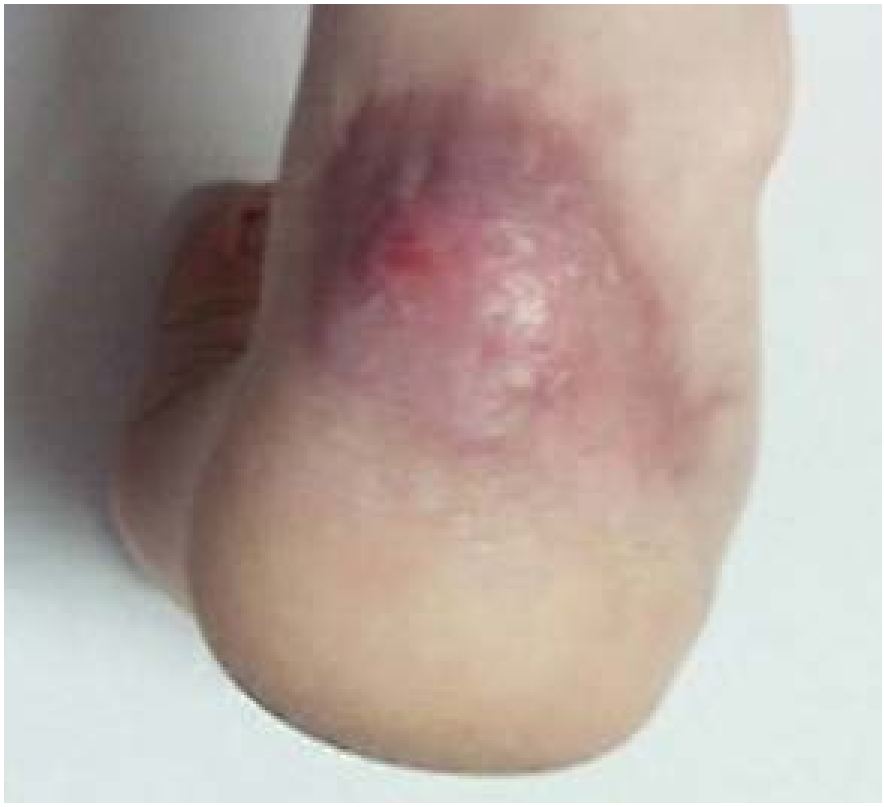

Figure 5. Final outcome with dermal matrix fully vascularized.

the center of the matrix over the calcaneus. The silicon layer began to peel off. Due to the opaque coloring of the secretion on the bandages, we decided to remove the silicone layer and apply a split-thickness skin graft to cover the defect, even though a nonvascular part of dermal matrix was centrally present.

The boy underwent another operation under general anesthesia. A split-thickness skin graft was placed on the dermal matrix. Following the surgery, the boy was prescribed strict inactivity for the first few days. A green secretion was present on the dressings; the graft was healing without apparent signs of infection. A 0.5 cm^2 non-vascularized dermal matrix was present above the calcaneus where the skin graft did not heal; a dermal matrix was preserved (Figure 4).

During hospitalization the secretion reduced, and the boy was discharged home. In outpatient care a hydrocolloid dressing was applied to the remaining defect weekly, and the remaining defect slowly healed from the edges. At the final examination, the dermal matrix was fully vascularized and the skin defect was completely healed (Figure 5).

Discussion

A difficult case of a skin defect of the foot was discussed. If a free flap that provided excellent coverage with high-quality tissue had been used, additional demanding surgery would have been needed. If successful, the boy's rehabilitation would have been relatively short. A free flap would still have been overabundant for the foot area, and the boy would have needed another surgery to reduce the volume of the free flap. An additional trauma created at the site of the injury is another disadvantage of the free flap. The use of negative pressure therapy is an alternative treatment option in defects like this because it does not cause additional trauma. However, it does take longer to heal, prolonging the time of exposure of deep tissues to desiccation and possible infection. We decided to use a dermal matrix. During the first, rather simple operation, the defect was covered with a dermal matrix and a system for negative pressure therapy was applied to it. After a month, another operation followed, during which the silicone coverage was removed and a split-thickness skin graft was used to cover the defect. The vascularization process lasted longer than was initially

estimated, and healing was prolonged due to the incomplete vascularization of the dermal matrix. The final result was aesthetically and functionally satisfactory.

Conclusion

Dermal matrix and local and free flaps can be used to cover a skin defect after trauma. Flaps provide good skin coverage and a short period of rehabilitation; however, the surgery is extremely demanding. The use of a dermal matrix to cover defects is evolving and offers an alternative treatment. This approach provides aesthetically and functionally satisfactory results.

Parental consent was obtained for publication of this article.

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Laparoscopic Insertion of a Pelvic Tissue Expander to Prevent Radiation Enteritis prior to Radiotherapy for Sacral Metastasis of Alveolar Maxillary Rhabdomyosarcoma: A Case Report

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Key words

radiation enteritis, pelvic tissue expander, laparoscopy

Case Report

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Abstract

In patients receiving external beam radiotherapy to the pelvis, radiation enteritis is a significant complication, particularly in patients receiving high-dose radiotherapy (> 80 Gy) and in those with a low pelvic peritoneal reflection, allowing loops of the small intestine to enter the radiation field. The lifelong morbidity of radiation enteritis has motivated attempts at a variety of surgical displacement procedures in the abdomen, pelvis, and retroperitoneum. Displacement of organs using omentum, tissue expanders, breast prostheses, and several types of mesh has been reported, but none of these methods have gained widespread usage. Morbidity related to the surgical procedure itself has raised some concerns. Laparoscopic insertion and subsequent removal of a pelvic tissue expander before and after external beam radiotherapy is a relatively convenient, safe, and effective method for displacing loops of intestine out of the pelvis. This can be done with minimal morbidity and convert previously untreatable patients into treatable patients who can receive relatively high doses of radiation. Here, we report a case of 15-year-old female with maxillary rhabdomyosarcoma involving the maxillary sinus with skeletal metastases who was scheduled for second-line treatment of metastases with radiotherapy. A tissue expander was laparoscopically inserted into the lower pelvis to displace intestinal loops from the radiation field to prevent radiation enteritis.

Introduction

Rhabdomyosarcoma is the most common soft tissue sarcoma seen in childhood and adolescence. The most frequent site is the head and neck, accounting for 40% of all cases. Other sites involved are the genitourinary tract, retroperitoneum, and, to a lesser extent, the extremities. Here, we report the case of a 15-year-old female with maxillary rhabdomyosarcoma involving the maxillary sinus with skeletal metastases. As primary treatment, according to RMS 2005 protocol (1), she received nine cycles of chemotherapy. The primary maxillary tumor of the maxillary sinus was surgically removed after four cycles of chemotherapy. With the sixth cycle of chemotherapy, radical radiotherapy of the primary tumor location and metastases in the spinal vertebrae, ribs, pelvis, and left femoral bone started what led to complete regression of skeletal metastases. In the course of maintenance therapy, MRI scan showed a 12 × 28 × 23 mm lesion in the sacrum in the vicinity of the right sacroiliac joint with characteristics of metastasis. After that, a second line of treatment was started with chemotherapy and radiotherapy.

In patients receiving external beam radiotherapy (EBRT) to the pelvis, radiation enteritis is a significant complication of EBRT, particularly in patients receiving high-dose radiotherapy (> 80 Gy) and in those with a low pelvic peritoneal reflection, allowing loops of the small intestine to enter the radiation field (2, 3). Often the morbidity and impact of the side effects of radiation treatments can become worse than the original disease (4). The lifelong morbidity of radiation enteritis from conventional radiation treatments has motivated attempts at a variety of surgical displacement procedures in the abdomen, pelvis, and retroperitoneum (5–16). Displacement of organs using omentum, tissue expanders, breast prostheses, and several types of mesh has been reported, but none of these methods have gained widespread use. Despite some apparent advantages, these methods have not entered mainstream clinical practice. For conventional radiation techniques, the benefit is often not worth the extra surgical morbidity. The dose to other adjacent structures usually remains high even with displacement.

Because the region of the right sacroiliac joint with the intestine was already included in primary radiation treatment in our patient, a tissue expander was laparoscopically inserted in the lower pelvis to displace intestinal loops from the radiation field to prevent radiation enteritis.

Case Presentation

In our case, this patient with sacral metastasis of alveolar maxillary rhabdomyosarcoma would ordinarily not have been a candidate for EBRT due to intestinal loops low in the pelvis. Laparoscopic insertion of a tissue expander into the pelvis to displace the intestinal loops was her only option. With laparoscopic insertion and subsequent removal of the tissue expander, she was able to receive radiotherapy to the sacrum without developing radiation enteritis.

No intestinal preparation was required. A 10 mm supraumbilical incision was made and an open Hasson technique was used to achieve pneumoperitoneum, with the placement of a 10 mm port at the umbilicus and 5 mm ports in both iliac fossae. Soft adhesions in the lower pelvis were divided by scissor dissection. In lithotomy and steep Trendelenburg positioning, the suprapubic incision was dilated up to 20 mm. A MENTOR®Smooth Rectangle Tissue Expander (10.6 × 9.3 × 6.6 cm) 400 ml made of silicone with attached silicone tubing was then rolled tight, lubricated with water-soluble lubricant, and inserted via the suprapubic port and placed laparoscopically in the pelvis, leaving the normal-saline inflation port attached externally (Figure 1, Figure 2).

A running dissolvable 2/0 polydioxanone (PDS) purse-string stitch was then sutured to the peritoneum of the sacral promontory and the anterior and side walls of the pelvis below the level of the common iliac vessels and tied snugly to keep the expander in the pelvis. With a Huber® needle inserted into the inflation port, the tissue expander was then filled with 340 ml of normal saline until the expander began to bulge against the retaining stitch (Figure 3).

The abdomen was then deflated of gas and the fascia of both the Pfannenstiel and umbilical port closed. The port of the expander was then placed in a small subcutaneous pocket and sutured to the fascia of the anterior abdomen. Skin incisions were closed in the usual manner (Figure 4).

Subsequent CT scan confirmed adequate placement of the expander device in the pelvis with the

Figure 1. Rolled tissue expander.

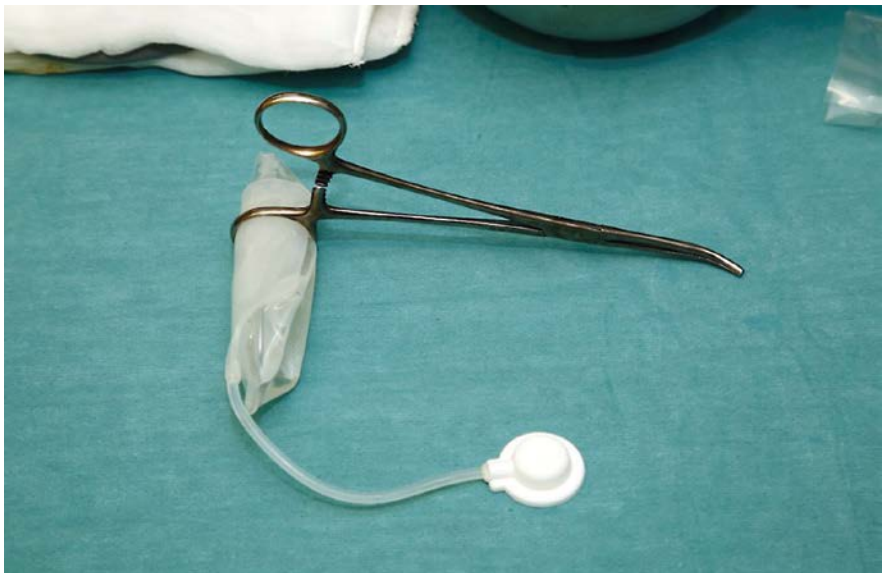


Figure 2. Insertion of the tissue expander.

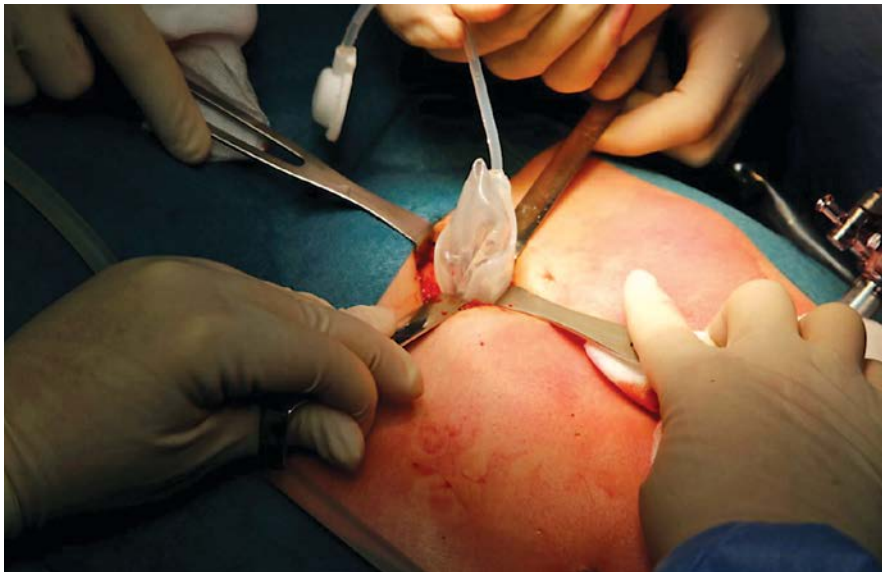
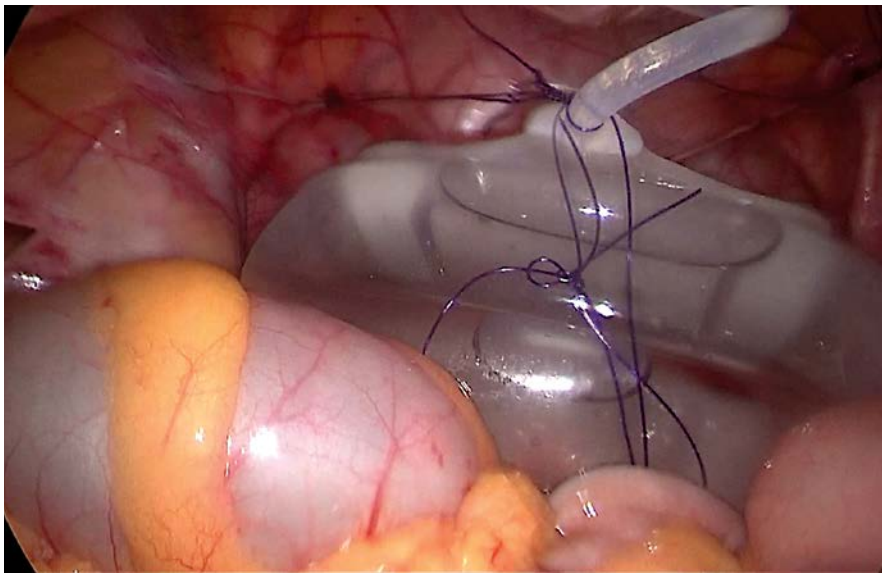


Figure 3. Bulging of the expander.



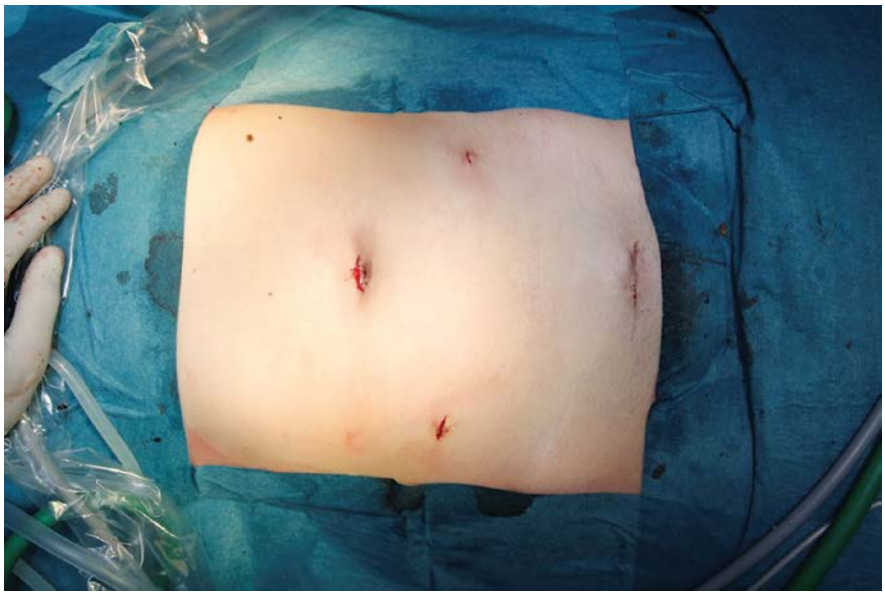


Figure 4. Skin incisions closed.

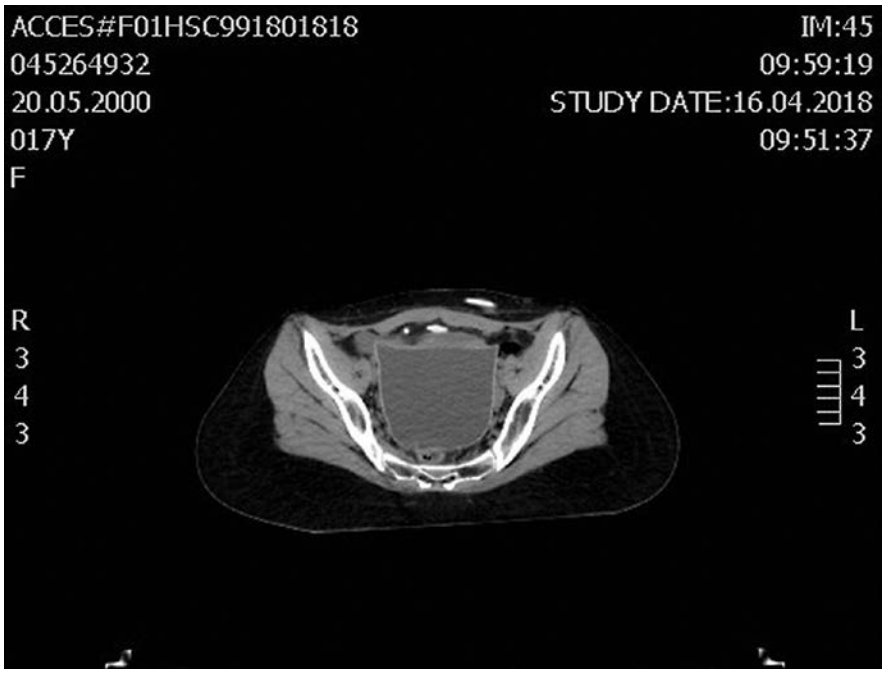


Figure 5. CT scan after tissue expander insertion: intestinal loops out of the pelvis.

intestinal loops now well out of the pelvis and the planned radiation field (Figure 5).

The patient's recovery was uneventful, and she was discharged after 2 days. Two weeks later she went on to have EBRT to her sacrum, achieving a good response without any side effects or symptoms. Repeat CT prior to removal of the expander showed a well-placed expander within the pelvis, with no evidence of radiation injury to the small intestine or the prosthesis.

The tissue expander was removed laparoscopically 6 weeks after radiotherapy completion using the same initial incisions, with a good cosmetic result. There were minor adhesions to the silicone implant, and the PDS retaining string was intact, but it easily broke with a gentle tug. These two factors facilitated its easy laparoscopic removal.

After a year of follow up, the disease is in remission and the patient is without any major complaints. Ultrasound examinations and skeletal scintigraphy were both negative regarding the progress of rhabdomyosarcoma.

Discussion

In general, the effectiveness of any form of radiation treatment is limited by the tolerances of adjacent normal tissues. The acute and chronic toxicity of radiation (especially to the intestines) continues to confound our therapies (2, 3). Radiation enteritis causes considerable disability and can be avoided in many cases. Any patient receiving pelvic EBRT should undergo a planned CT scan, with particular attention given to patients with a low peritoneal reflection and intestinal loops within the planned radiation field.

Methods of reducing injury to the small intestine include multifield conformal therapy with prior three-dimensional planning where the profile of the radiation beam is shaped to fit the target. The delivery of intensity-modulated radiotherapy can also be adjusted, and it improves the ability of treatment volumes to conform to the shape of the tumor. Despite these techniques, intestinal loops are still occasionally injured from being in the radiation field. If available, brachytherapy or cryotherapy may be reasonable alternatives to EBRT. Where EBRT is the preferred or only option, there are various methods for removing small intestine from the radiation field. Conventional nonoperative maneuvers to remove small intestine from the pelvis at the time of administering radiotherapy include extreme prone or Trendelenburg positioning, bladder distension, abdominal wall compression, or the use of an open table-top device (belly board) (5). The response of such maneuvers is not always reproducible. More extreme measures described only in case reports include surgical insertion of a peritoneal dialysis catheter and creation of a temporary artificial pneumoperitoneum or ascites with the installation of gas or normal saline into the abdominal cavity (6, 7). These are time-consuming and painful, need to be repeated, and do not reliably remove intestine from the radiation field.

Normal saline-filled silicone tissue expanders are easy to insert and remove and have the benefit of being non-adherent to both the peritoneum and small intestine. They are radioresistant to degradation and, when filled with normal saline, are similar in density to human tissues, and therefore do not alter the isodose distribution of radiotherapy. Early experience with tissue expanders found that complications were more common when large expanders were left in the pelvis long-term, with the potential for bladder, ureteric, and iliac vessel compression. Heaviness is a common complaint with very large expanders (8). Deep vein thrombosis with pulmonary embolism and constipation due to obstructive defecation have been reported (8, 9). More recent reports using smaller implants show them to be associated with fewer complications (10). Infection with abscess formation and fistulization have been reported to occur in up to 7% of cases (11). Wound infections associated with large laparotomy incisions are not uncommon, particularly when the incision extends into the radiation field (12). Another disadvantage of tissue expanders is that they do very little to prevent radiation injury to the bladder or rectum, with radiation cystitis (13) and proctitis still being common complications.

In our case, a conventional 400 ml normal saline-filled silicone tissue expander without suture tabs was used, and it was kept in the pelvis by means of a PDS purse-string suture. This monofilament has a tensile-strength half-life of 5 weeks, with significant degradation of the suture at 10 to 12 weeks. Therefore, removal of the expander was performed easily by gentle traction alone. However, with dissolvable sutures, there is a risk of tissue expander migration, and therefore a non-dissolvable suture may also be appropriate. The choice of a conventional sized expander and the avoidance of overfilling were challenging because of literature reports of the risks of ureteric and iliac vessel compression.

For pelvic lesion, adequate and stable displacement of the intestine in the pelvis is, at present, a promising technique. The upper abdomen remains problematic due to the large number of closely associated organs as well as the motion imparted by the diaphragm (16). Evidence of metastatic disease makes these complex pursuits futile in most instances, where there can be no significant impact on morbidity and survival. All of this can make patient selection for radiotherapy treatment demanding.

Conclusion

Laparoscopic insertion and subsequent removal of a pelvic tissue expander before and after EBRT is a relatively convenient, safe, and effective method for displacing intestinal loops out of the pelvis. This can be done with minimal morbidity and can

convert previously untreatable patients into treatable patients who can receive relatively high doses of radiation. The ease, simplicity, reversibility, and minimally invasive nature of laparoscopic tissue expander insertion are its main appeal. It should be considered as an option for excluding the small intestine from the pelvis prior to radiotherapy of the sacrum. These combined techniques offer the double hope of more effectively treating a difficult cancer and also diminishing or eliminating the costly and disabling effects often seen with conventional radiation. Opportunities are open for valuable collaboration and innovation in this area, especially in the further development of minimally invasive displacement techniques.

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Near-Infrared Indocyanine-Green Fluorescence Imaging for Lymphatic Mapping in Colorectal Cancer

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Key words

indocyanine-green, lymphatic mapping, colon cancer, near-infrared fluorescence

Study Protocol

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Abstract

Background. When dealing with colon cancer, both local and distant disease recurrence must be appropriately addressed. The primary tumor with its associated lymph node basin must be resected. Determination of the mesentery division line thus ensuring an appropriate degree of lymphadenectomy is critical. Real-time visualization of lymphatic drainage could hypothetically help in achieving this goal.

Methods. A prospective non-randomized study of colon cancer patients undergoing curative laparoscopic resection will be performed. Peritumoral subserosal ICG injection will be performed intraoperatively to demonstrate lymphatic drainage of the tumor. A D-Light NIR/ICG (Karl Storz, Germany) system will be used to assess the lymphatics. The primary goal will be to assess the feasibility of indocyanine-green (ICG) fluorescence imaging for assessing lymphatic mapping in colon cancer.

Discussion. It is hoped that study will prove the hypothesis that ICG fluorescence is feasible and successfully demonstrates lymphatic drainage of the tumor. Hence, this could help in achieving adequate lymphadenectomy. Moreover, the results of mapping could possibly obviate the need for an extended resection on the one hand or be an indication for it on the other.

Introduction

When dealing with colon cancer, both local and distant disease recurrence must be appropriately addressed. A primary tumor with its associated lymph node (LN) basin must be resected. When excising the tumor, all the resection margins must be free of disease (R0 resection). This is relatively consistently achieved; however, the extent of mesenteric lymphadenectomy is variable. En bloc resection of the lymphatic basin that drains the tumor is a pillar in achieving local control of the disease,

but it is also a basis for cancer staging that drives the decision for appropriate adjuvant treatment planning. Hence, it affects overall survival. The AJCC recommends that at least 12 LNs be harvested if final staging is to be accurate (1).

Some authors believe that excising the mesentery should follow the principles of complete mesocolic excision (CME) with central vascular ligation (CVL), thus ensuring resection along embryological tissue planes with the entire regional mesocolon being excised and an intact peritoneal and fascial line package. This presumably leads to better overall survival due to a greater number of LNs and an oncologically superior specimen (2). However, true consensus for CME is lacking because there are concerns over increased morbidity after such extended resections. Lymphatic mapping could therefore potentially identify the drainage LN basin with its true status and possible aberrant drainage roots. Hence, a "tailored" instead of "radical" lymphadenectomy could be carried out, avoiding the need for CME with the associated risks for postoperative morbidity (3).

The primary goal of the study will be to assess the feasibility of indocyanine-green (ICG) fluorescence imaging for assessing lymphatic drainage in colon cancer. Secondary goals will be: 1) assessing the impact of ICG mapping on the overall number of LNs procured, and 2) assessing the ratio between the number of overall LNs procured and positive LNs in the mesentery, additionally resected whenever this will be necessary because of the ICG mapping

Methods

Study Design and Patients

The study will prospectively identify 50 consecutive patients with colon cancer from the multidisciplinary team (MDT) meeting at the author's tertiary referral center. Patients will be enrolled in the study if they are over 18 years of age, diagnosed with primary colon cancer proximal to the rectosigmoid junction, able to undergo routine staging with intravenous contrast-enhanced CT, and able to tolerate mechanical bowel preparation for surgery. Patients will be excluded if they are under 18, have bowel obstruction or an urgent resection or surgery for palliative intent is needed, and/or have distant metastases or an allergy or history of adverse reaction to ICG, iodine, or iodine dyes. All patients will have a preoperative workup in line with the Slovenian national guidelines for management of patients with colorectal cancer. These include a colonoscopy with tissue biopsy confirming adenocarcinoma of the colon, staging for distant metastasis with a CT scan of the chest and abdomen, and presentation of each patient's case at an MDT meeting.

Patient and tumor demographics, and operative and other procedural details will be assessed. These will include age, sex, preoperative staging, the procedure performed, data on whether the visualization of the lymphatic drainage was successful, the presence of LNs outside the proposed line of mesenteric resection, the pathological stage, the number of LNs procured, the number of positive LNs, the number of whole LNs, and among these the number of positive LNs in the mesentery dissected outside the proposed line of resection.

Technique

Tumors will be marked with India ink at the time of the index colonoscopy to assist intraoperative identification. Surgical resection (laparoscopic colectomy per routine) will be performed by a group of dedicated colorectal surgeons well trained in minimally invasive surgery. A multiport laparoscopic approach will be performed. Two techniques will be employed, as per the surgeon's own preference. In the laparoscopically assisted technique, following ligation of the main vascular pedicle (the ileocolic artery or inferior mesenteric/ascending left colic artery) and mobilization of the colon, the specimen will be extracorporalized through a small midline incision using a wound retractor. A subserosal injection of 1 ml of ICG (5 mg / 10 ml) will then be placed in four sites around the tumor (4 ml in total). Using a D-Light NIR/ICG (Karl Storz, Germany) system, the ICG will be excited by light in the near-infrared (NIR) spectrum, for image comparison in standard white light and NIR, and with real-time visualization of the lymphatic drainage. In the total laparoscopic technique, all the steps will be identical, except there will be no extracorporalization of the colon. Both subserosal injection of ICG as well as real-time lymphatic mapping will be performed

intracorporeally. At the end, the specimen will be extracted through a mini-Pfannenstiel incision. In both techniques, special wound protectors will be used to avoid fecal contamination or spillage of tumor cells.

Descriptive statistics will be used to describe the outcomes, including means (with standard deviation), medians (with range), and values (with percentage).

Approval for the study was obtained from the Medical Ethics Committee of the Republic of Slovenia, the Protocol Review Board (MZ 0120-362/2019/5). Written consent from all patients included will be provided prior to study enrollment.

Discussion

Lymphatic mapping philosophically differs from sentinel LN (SLN) identification in terms of selective removal of the mesocolon draining a tumor. ICG fluorescence technology could lead to more precise minimally invasive surgery, guiding optimal oncologic resections without the need for risk-associated CME. Regardless of CME, ICG fluorescent lymphangiography could elucidate the correct mesocolic resection margin, resulting in better lymphadenectomy as well as influencing the recommendations for adjuvant therapy. Second, aberrant LN not seen in preoperative imaging or acknowledged during the operation could be identified and removed. This was clearly shown by Chand et al. in their prospective pilot study of colon cancer patients undergoing curative laparoscopic resection. They evaluated ICG fluorescent lymphangiography in 10 consecutive patients. In all of them, lymphatic channels were seen at least to some extent, and, moreover, eight had drainage to SLNs. In two cases, the resection was extended due to the discovery of additional LNs; in both cases, these were positive in the final pathology (4). Cahill et al. found that four out of 18 patients analyzed had fluorescing SLNs outside the previously planned resection area (5). Similar results were reported by Nishigori et al. They performed ICG fluorescent visualizations in 21 patients, including for blood and lymph flow. Their surgical plan for the lymphadenectomy had to be changed in 23.5%. According to their results, the metastatic rate of ICG-positive nodes was 10% and the metastatic rate of ICG-negative nodes was 5.3% (6). Even if one accepts CME with central vascular ligation as a state-of-the-art colon cancer treatment, thereby neglecting voices of concern over postoperative morbidity, ICG fluorescent lymphatic mapping could be very useful in laparoscopic surgery for colon cancer located in the hepatic or splenic flexure. Lymphatic drainage at these sites can vary and the precise site of lymphatic dissection is uncertain (7, 8). Cancer in the splenic flexure has several lymphatic drainage roots. These can be the left branch of the middle colic artery and left colic artery (LCA) areas in addition to the left accessory aberrant colic artery when present. Moreover, drainage pathways to the infrapancreatic node region and the splenic hilum is also possible. These kinds of lymph flow patterns were evaluated in a study by Watanabe et al. that included 31 patients with non-metastatic splenic flexural cancer with a preoperative diagnosis of N0. According to their results, lymph node dissection at the root of the inferior mesenteric vein (IMV) is important; however, both the middle colic artery and the left colic artery may not necessarily need to be ligated. Based on their findings, they also recommended specific CME types for different tumor localizations: for cancers in the first part of the descending colon, a CME with LN dissection of the LCA and the root of the IMC area is to be undertaken; the distal third of the transverse colon cancer requires CME with lymphadenectomy of the MCA and the root of the IMV areas. Colon cancer located in the splenic flexure can have lymphatic drainage in different directions. The results of their study did not show lymphatic drainage to both the LCA and MCA, hence they believe that ligation of both vessels is not absolutely needed (9).

It is hoped that the results of this study will prove the hypothesis that ICG fluorescence is feasible and successfully demonstrates lymphatic drainage of the tumor, which was already shown by some authors in a limited series. Hence, this could help surgeons in achieving adequate lymphadenectomy. Moreover, the results of mapping could possibly obviate the need for an extended resection on one hand or be an indication for it on the other.

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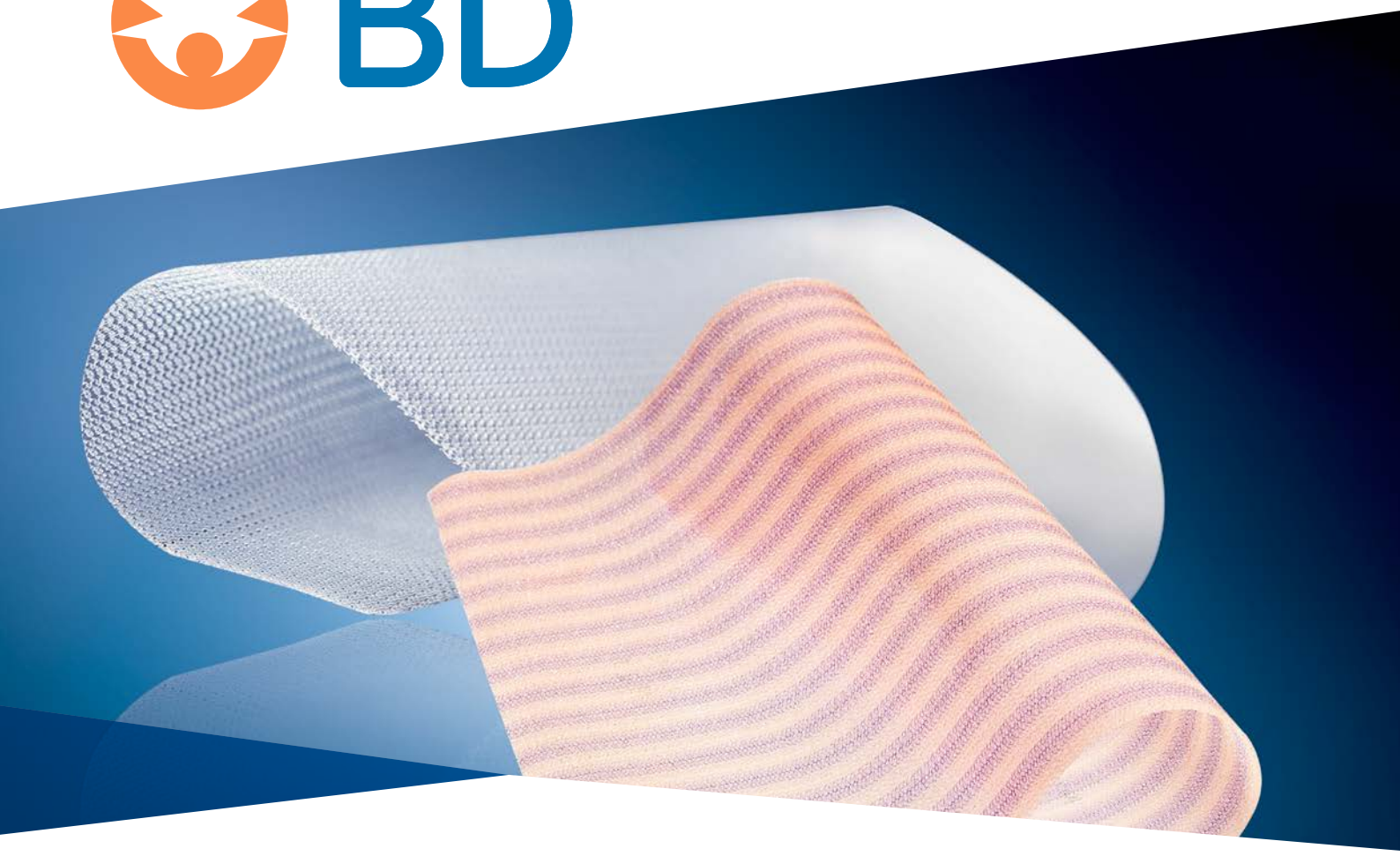

Phasix™ Mesh
Phasix™ ST Mesh

Fully Resorbable Implant for Soft Tissue Reconstruction

- Phasix™ ST Mesh combines two market-leading technologies into one product: monofilament resorbable Phasix™ Mesh and a proven hydrogel barrier based on Sepra™ technology.
- Sepra™ hydrogel barrier on posterior side of Phasix™ ST Mesh minimises visceral tissue attachment[1]
- Woven monofilament mesh scaffold using Poly-4-hydroxybutyrate (P4HB), a biologically derived, fully resorbable material.
- Monomer form (4HB) is a naturally occurring human metabolite found in the brain, heart, liver, kidney, and muscle.

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Instructions for Authors

Surgery and Surgical Endoscopy is the official journal of the Slovenian Society of Endoscopic Surgery. It is a multidisciplinary journal devoted to publishing original and high-quality scientific papers, pertinent to surgery, surgical oncology as well as surgical endoscopy.

The Editorial Board requires that the paper has not been published or submitted for publication elsewhere. The authors are responsible for all statements in their papers. Accepted articles become the property of the journal and, therefore, should not be published elsewhere without the written permission of the editors.

1. SUBMISSION OF THE MANUSCRIPT

The journal accepts *review articles, research articles, case reports, letters to the editors, study protocols and "How I do it" submissions.*

The manuscript written in English should be submitted to Editors-in-Chief, Tomaž Jagrič or Jan Grosek (tomaz.jagric@gmail.com; jangrosek@gmail.com).

All articles are subjected to the editorial review. The editorial board reserves the right to ask authors to make appropriate changes of the contents as well as grammatical and stylistic corrections when necessary.

Articles are published printed and on-line as the open access (www.zeks.si/journal). There is no publication fee.

When manuscripts are submitted under multiple authorship, it is the corresponding author who has the authority to act on behalf of all the authors in all matters pertaining to publication. Submitted manuscripts are reviewed by the editorial board on the assumption that all listed authors concur in the submission and are responsible for its content.

2. PREPARATION OF MANUSCRIPTS

The manuscript should be submitted as .doc or .docx file. It should be written in grammatically and stylistically correct language. Abbreviations should be avoided. If their use is necessary, they should be explained when first mentioned in the text. The chapter headings should not contain abbreviations. The technical data should conform to the SI system. Each section should be started on a new page, and each page should be numbered consecutively with Arabic numerals.

The Title page should include a concise and informative title, followed by the full name(s) of the author(s); the institutional affiliation of each author; the name and address of the corresponding author (including telephone, fax and E-mail). Authors should be qualified for authorship. They should contribute to the conception, design, analysis and interpretation of data, and they should approve the final version of the contribution.

This should be followed by the abstract page, summarizing in less than 250 words the reasons for the study, experimental approach, the major findings (with specific data if possible), and the principal conclusions. Three to six key words should be provided for indexing purposes. Structured abstracts are required for research articles only.

Review Articles

The Editorial Board encourages submission of review articles on topics of current interest. The manuscript should be restricted to 5000 words and up to 50 references. An abstract of no more than 250 words and up to six key words should be provided.

Research Articles

The abstract of the research article should be structured (Background, Methods, Results, Conclusions) and of no more than 250 words (Slovenian language abstracts are limited to 400 words).

Research article should be structured as well, divided into sections: Introduction, Methods, Results and Discussion. Manuscript should be restricted to 4000 words.

Introduction should summarize the rationale for the study or observation, citing only the essential references and stating the aim of the study.

Materials and methods should provide enough information to enable experiments to be repeated. New methods should be described in detail.

Results should be presented clearly and concisely without repeating the data in the figures and tables. Emphasis should be on clear and precise presentation of results and their significance in relation to the aim of the investigation.

Discussion should explain the results rather than simply repeating them as well as interpret their significance and draw conclusions. It should discuss the results of the study in the light of previously published work.

Case Reports

This section presents reports on rare or otherwise interesting case report or case series. Articles must be authentic, ethical, educational and clinically interesting to an international audience of surgeons, trainees and researchers in all surgical subspecialties, as well as clinicians in related fields.

The manuscript should be in the format:

- Introduction
- Case report/case presentation
- Discussion

Submissions to this section should carry no more than 2500 words, two figures and 20 references. An unstructured abstract of up to 200 words and six key words should be provided.

Letters to the Editor

Comment on papers recently published in the Journal. The letters should be restricted to up to 500 words and three references and should not carry any figures.

Study Protocol

Study protocol articles can be for proposed or ongoing prospective clinical research, and should provide a detailed account of the hypothesis, rationale and methodology of the study. Study protocols for pilot or feasibility studies will be treated on a case by case basis. Study protocols without ethics approval will generally not be considered. The manuscript should be structured the same way as a research article.

How I Do It?

Submissions to this section should provide description of a well-established procedure focussing on its technical aspects. The manuscript should be in the format:

- Introduction
- Preoperative preparation
- Operative steps
- Postoperative care

The operative steps should be illustrated with high-quality figures. The manuscript should be restricted to 1500 words, a 150-word abstract, six key words and may carry up to 10 figures and 10 references.

3. DECLARATIONS

All manuscripts must contain the following sections under the heading "Declarations".

- Ethics approval and consent to participate
- Consent for publication
- Competing interests
- Authors contributions
- Funding
- Acknowledgements

If any of the sections are not relevant to your manuscript, please include the heading and write "Not aplicable" for that section.

a) Ethics approval and consent to participate

Manu scripts reporting studies involving human participants, human data or human tissue must:

- include a statement on ethics approval and consent (even where the need for approval was waived), and
- include the name of the ethics committee that approved the study and the committee's reference number if appropriate.

Studies involving animals must include a statement on ethics approval. If your manuscript does not report on or involve the use of any animal or human data or tissue, please state "Not applicable" in this section.

b) Consent for publication

If your manuscript contains any individual person's data in any form (including any individual details, images or videos), consent for publication must be obtained from that person, or in the case of children, their parent or legal guardian. All presentations of case reports must have consent for publication. You should not send the form to us on submission, but we may request to see a copy at any stage (including after publication). If your manuscript does not contain data from any individual person, please state "Not applicable" in this section.

4. REFERENCES

References must be numbered in the order in which they appear in the text and their corresponding numbers quoted in the text. Authors are responsible for the accuracy of their references. References to the Abstracts and Letters to the Editor must be identified as such. Citation of papers in preparation or submitted for publication, unpublished observations, and personal communications should not be included in the reference list. If essential, such material may be incorporated in the appropriate place in the text. References follow the style of Index Medicus, DOI number (if exists) should be included. All authors should be listed when their number does not exceed six; when there are seven or more authors, the first six listed are followed by "et al.". The following are some examples of references from articles, books and book chapters:

1. Dent RAG, Cole P. In vitro maturation of monocytes in squamous carcinoma of the lung. Br J Cancer 1981; 43: 486-95. doi:10.1038/bjc.1981.71
2. Chapman S, Nakielny R. A guide to radiological procedures. London: Bailliere Tindall; 1986.
3. Evans R, Alexander P. Mechanisms of extracellular killing of nucleated mammalian cells by macrophages. In: Nelson DS, editor. Immunobiology of macrophage. New York: Academic Press; 1976. p. 45-74.

5 . CHARTS, ILLUSTRATIONS, IMAGES AND TABLES

Charts, Illustrations, Images and Tables must be numbered and referred to in the text, with the appropriate location indicated. Each of them should contain a title and an explanation of all the abbreviations and non-standard units used. Charts, Illustrations and Images, provided electronically, should be of appropriate quality for good reproduction and should be submitted as separate files. Illustrations and charts must be vector image, created in CMYK colour space, preferred font "Century Gothic", and saved as .AI, .EPS or .PDF format. Colour charts, illustrations and Images are encouraged, and are published without additional charge. Image size must be 2.000 pixels on the longer side and saved as .JPG (maximum quality) format. In Images, the identities of the patients should be masked. Tables should be typed double-spaced. The files with the figures and tables can be uploaded as separate files.

6. PAGE PROOFS

Page proofs will be sent by E-mail to the corresponding author. It is their responsibility to check the proofs carefully and return a list of essential corrections to the editorial office within three days of receipt. Only grammatical corrections are acceptable at that time.

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