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Review

Laparoscopic surgery update for gastrointestinal malignancy

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Introduction

Laparoscopic gastrointestinal (GI) surgery has been associated with less posteperative pain, an early return of bowel function, a shorter period of hospitalization and disability, and better cosmetic results. Surgeons have adopted the laparoscopic procedure for cholecystectomy, and it has become the standard surgical treatment for cholecystolithiasis within a short period.[1] Unlike cholecystectomy, very few other GI operations are performed routinely with laparoscopic techniques. The percentage of surgeons performing laparoscopic colorectal operations in the United States has decreased over the past several years, especially for malignancies.[2] In this article, we review the problems associated with GI laparoscopy for malignancies, and the outcome that laparoscopic surgeons have achieved is analyzed. We intend to encourage more adoption of laparoscopic procedures for GI disease and to familiarize the gastroenterologist with advanced laparoscopic procedures, including our inventions.

Laparoscopic procedures for gastrointestinal disease

General outline of laparoscopic operation

Unlike open surgery, a laparoscopic approach implies performing a procedure inside the body with instruments inserted from the outside through surgical ports. All laparoscopic surgery is performed under general anesthesia. A flexible or rigid laparoscope is used for visualization, and surgeons perform operations under the guidance of a videoscopic view on a monitor. Several additional ports for working forceps or scissors are inserted under videoscopic view. All laparoscopic procedures are performed with long straight instruments that are introduced through the working ports; these include scissors, forceps, knives, and those associated with electrocautery and suction. These instruments are limited in their motion by the fixation enforced by the abdominal wall ports. The peritoneal cavity can be expanded by insufflation of CO_2 gas to 10 mmHg, allowing creation of a large space between the anterior abdominal wall and intraperitoneal viscera. Laparoscopic surgery requires surgeons to infer the shape of the internal organs of patients from two-dimensional (2-D) displays on a video monitor. Surgeons perform operations with no tactile feedback to their hands and with a motion limitation dictated by the laparoscopic instruments.

Although early in the era of laparoscopic surgery previous abdominal operations were considered as a relative contraindication to laparoscopic procedures, currently most patients with postoperative adhesion are amenable to a laparoscopic approach by careful dissection of the adhesions under videoscopic view.

Instruments for GI laparoscopic operation

Laparoscopic instruments have been developed in response to the laparoscopic era. In contrast to laparoscopic cholecystectomy, the viscera resected by the GI laparoscopic procedure are bulky and abundant with blood supplied from large-caliber vessels. Specialized instruments for advanced laparoscopic procedures including GI laparoscopic surgery are required to perform operations safely and easily.

Probably one of the most difficult techniques performed during these advanced laparoscopic procedures

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is the ligature of vessels for hemostasis.[3] This technique is essential for the safe removal of GI lesions, as well as for hemostasis of accidental bleeding. Massive bleeding cannot be controlled securely using metal clips because such clips are designed for cystic arteries and ducts during laparoscopic cholecystectomy. Intracorporeal and extracorporeal methods for ligation have been reported.[4,5] We also developed a novel ligation forceps that introduces a secure and cheap method for ligation of vessels without the need for another forceps.[6] Using this instrument, ligation hemostasis also could be performed following temporary hemostasis of accidental bleeding with clamping forceps.

For the closure of small blood vessels without ligature, laparoscopic coagulation shears or a vessel-sealing system (Ligasure) is useful. These devices are safe for use in extended lymph node dissection and are associated with shorter operating time and less blood loss than with conventional hemostatic techniques.[7] Several internal stapling devices have been developed to allow for laparoscopic anastomosis or closure of hollow organs. The retracting devices are also employed to obtain working space in GI laparoscopic surgery. A flexible laparoscope with a charge-coupled device (CCD) on the tip provides a wide and clear view and is especially helpful in a narrow working space.[8] All these innovations can be introduced through a cannula of ports with a diameter of 5–18 mm. These technological innovations have supported the development of a laparoscopic procedure for GI disease. Most of these devices are disposable, which, regretfully, adds to the expense of laparoscopic procedures.

Development of a needle-like apparatus to reduce trauma for port access

Trauma at the access point can be reduced even further using a "needlescope" technique. In this laparoscopic operation, surgeons use fine forceps and scissors that are designed for use through ports smaller than 3 mm in diameter. A randomized trial has been published comparing needlescopic and conventional laparoscopic cholecystectomy.[9] In this study, 64 patients were randomly assigned to one of the two treatments. We concluded that the needlescopic approach did not offer any advantages over a conventional laparoscopy in terms of postoperative pain and recovery. However, the patients who underwent the needlescopic operation had an excellent cosmetic outcome. These instruments can be used for laparoscopic cholecystectomy. However, the viscera (stomach, colon, or esophagus) manipulated in the GI laparoscopic procedure are relatively large compared with the gallbladder, and the needle forceps is too fragile to manipulate the viscera in the GI tract. According to the concept of the needlescopic operation, we have developed two needle-type apparatuses for GI laparoscopic operation, 2 mm in diameter, which can be used to access the site without any surgical port by a direct, scarless puncture at the abdominal wall. The first development is a mini-loop retractor (Tyco Health Care Japan, Tokyo, Japan), which is used for the retraction of viscera with a wire loop.[10] This device can reduce the incision made for the port and provide adequate retraction of the stomach, colon, uterus, and esophagus with minimal tissue damage. In practice, laparoscopic cholecystectomy and colectomy can be performed with two conventional laparoscopic ports and two mini-loop retractors (Fig. 1). The second invention is a needle-type cautery probe. This probe can be connected to a conventional electric cautery holder. Surgeons can use the probe from a suitable direction for the coagulation and cutting of tissues (Fig. 1). Both the devices can access by a direct puncture of the abdominal wall, with no scar at all remaining. The instruments result in less injury at the port access and better cosmetic results.

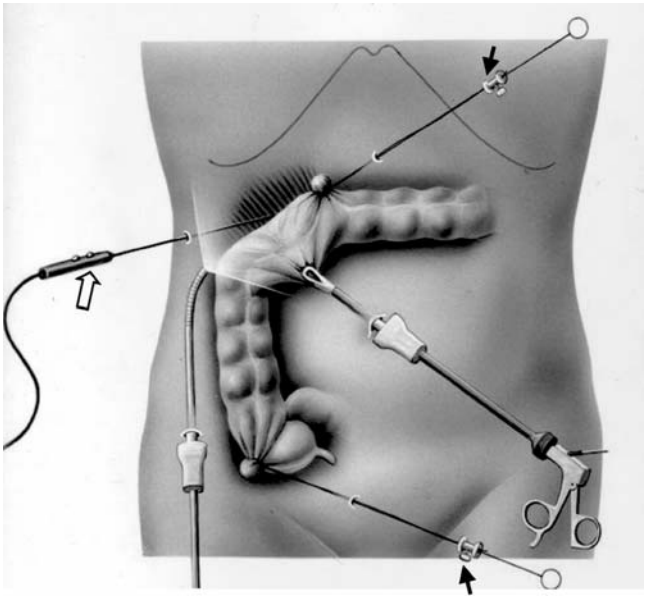

Fig. 1. Laparoscopic approach for right hemicolectomy with needle-like instruments. →, Mini-loop retractor that holds and retracts the colon; ⇨, electric cautery with a long and fine probe

As another approach to reduce pain at the port access wound, the effect of local anesthesia at the port site was evaluated, with decrease of postoperative pain being reported.[11]

Gasless procedure

In a laparoscopic operation, the pressure in the abdominal cavity is usually maintained at 10–12 mmHg by using a CO_2 insufflation unit. In obese patients, higher pres-

sure is necessary to lift the anterior abdominal wall. Under pneumoperitoneum with CO_2 gas, venous return to the heart from the infradiaphragmatic region may be compromised, and relative compression of pulmonary excursion by the elevated diaphragm may occur. Patients with severe cardiac or pulmonary disorders may be unable to tolerate these hemodynamic changes. Therefore, laparoscopic surgery is contraindicated for patients who are in shock. In addition, other immunological or oncological disadvantages of CO_2 insufflation have been shown in experiments with animal models.[12–14] To reduce the disadvantages of CO_2 insufflation, the possibility of performing the laparoscopic procedure with a low abdominal pressure of 7 mmHg was investigated.[15] The results showed that low-pressure laparoscopic cholecystectomy was successfully performed in 89% of patients with a body mass index (BMI) of less than 27.

Gasless laparoscopic surgery is also an alternative to laparoscopic surgery with CO_2 insufflation. With the gasless procedure, the hazardous effects of pneumoperitoneum can be avoided. In a gasless laparoscopy, an external mechanical retractor system is used to elevate the anterior abdominal wall away from underlying viscera. The abdominal pressure is equal to the atmospheric pressure during this operation, and it may be possible to avoid the disadvantages of CO_2 insufflation, including port site recurrence[16] and liver metastasis.[17] An advantage for surgeons is that a gasless operation permits the use of familiar instruments that are used in conventional surgery; however, the workspace is confined, and the videoscopic view is often impaired by the underlying viscera. In a randomized control study in patients with cholecystectomy, Uen et al. reported that the gasless procedure required a longer operation time, and they concluded that the technique may still have value in high-risk patients with cardiorespiratory diseases.[18] Recently, a report claimed that gasless laparoscopy has little effect on the hemodynamic parameters of patients.[19,20] The gasless procedure should be used only in selected patients with severe cardiopulmonary complications or advanced cancers to avoid the hazardous effects of the pneumoperitoneum.[21,22]

Hand-assisted laparoscopy

A fundamental difference from open surgery is that surgeons do not experience the tactile sensation of viscera or vessels in laparoscopic operations. A hand-assisted procedure was developed as an alternative to the laparoscopic operation to take advantage of the fact that the hand of the surgeon is the most useful of tools in an abdominal cavity. Many laparoscopic procedures require a small skin incision at the end of the operation to remove the resected specimen intact. In a hand-assisted laparoscopic surgery, the incision is made at the beginning of the operation. Usually, a 6 to 10-cm abdominal incision is made for the insertion of the surgeon's nondominant hand into the abdominal cavity, and a sealing system is used to maintain the pneumoperitoneum. It improves the identification of vessels or tissues and facilitates retraction during the complex procedure. However, the abdominal incision to insert the surgeon's hand to the abdominal cavity is relatively large and it impairs the less-invasive advantage of laparoscopic surgery. Therefore, this procedure should be used in the abdominal cavity in case of necessity for advanced surgical techniques, as occurs with intracorporeal suturing and advanced lymph node dissection.[23–27]

Staging laparoscopy and palliation for abdominal malignancy

For GI malignancy, the laparoscope is a useful diagnostic tool to determine the local involvement and dissemination to the abdominal cavity. In a study for laparoscopic staging of gastric cancer, Ozmen et al. reported that laparoscopy and computed tomography were better for accurately assessing serosal involvement, peritoneal seeding, and hepatic metastases.[28] The authors emphasized that staging laparoscopy allows the surgeon to choose a more effective treatment modality. In esophageal cancer, a laparoscopic assessment can be used to avoid unnecessary surgery. Recently, diagnosis of micro-dissemination in advanced gastric cancer was performed by means of reverse transcriptase polymerase chain reaction from the peritoneal lavage solution, which was obtained by a laparoscopic procedure.[29] The therapeutic strategy could be changed as a result of these laparoscopic diagnoses and staging in GI malignancy.

Intraoperative hyperthermia with chemotherapy for patients with peritoneal dissemination of gastric cancer has been reported. In this therapy, a laparoscope was used to confirm the presence of dissemination in the abdominal cavity, and the laparoscopic ports were used as an inlet and outlet for the heated solution.[30]

Laparoscopy can play an important role in the palliative care of cancer patients when performing procedures such as feeding tube placement or stoma formation. Laparoscopic gastrojejunostomy for the palliation of unresectable advanced gastric cancer was reported with excellent results with less suppression of immune function, lower morbidity, and earlier recovery of bowel movements than with open gastrojejunostomy.[31] The use of laparoscopy in the care of patients with far-advanced malignancies should be carefully

evaluated because this technique can adversely affect survival or quality of life.

Laparoscopic surgery with curative intent for gastrointestinal malignancy

Colon cancer

Use of the GI laparoscopic approach in the area of colorectal disease started in 1991.[32] Subsequently, in a great number of studies reporting on the use of the laparoscopic procedure in colorectal surgery, it has been associated with less postoperative pain, an early return of bowel function, a shorter period of hospitalization, better cosmetic results, and better patient satisfaction. Laparoscopic surgery for benign colorectal disease has been proven to be safe and feasible. Laparoscopic stoma formation, laparoscopic resection for diverticular disease and Crohn's disease, laparoscopic rectopexy, and laparoscopic-assisted reversal of Hartmann's procedure have been reported.[33–38] The application of laparoscopic techniques is probably as well accepted for the treatment of benign lesions of the colon as for that of early colon cancer.[39] The indication of laparoscopic procedures for colon malignancies with a curative intent has been controversial in these past 10 years. Laparoscopic resection for colorectal cancer has not been recommended except for randomized, controlled trials due to the unexplainable recurrence after laparoscopic operation on patients with advanced colorectal cancer.[40] The results of questionnaires from members of the Society of American Gastrointestinal Endoscopic Surgeons (SAGES) and the American Society of Colon and Rectal Surgeons (ASCRS) indicated that the overall percentage of surgeons performing laparoscopic colorectal surgery has decreased over the past several years; moreover, surgeons have been more hesitant to perform laparoscopic surgery for the cure of colonic cancer.[2] Recently, long-term survival rates after laparoscopic colon resection for adenocarcinoma of the colon have been reported from several groups.[41–46] Although long-term follow-up data are still limited, the results of these large prospective studies show that recurrence and survival rates after laparoscopic colon resection for malignancy were comparable to data after conventional surgery. These data should encourage surgeons to again perform laparoscopic procedures in potentially curable colon cancer cases; thus, the applicability of laparoscopy to colorectal disease will expand. It is necessary that surgeons be fully informed of the drawbacks of laparoscopic procedure for malignancy, as described below for laparoscopic operations on patients with curable colorectal cancer, especially when laparoscopy is performed on patients with advanced cases.

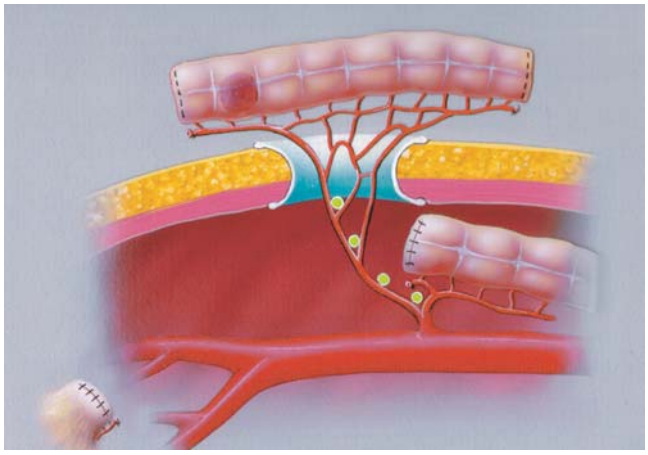

Fig. 2. Simple technique for dissecting lymph nodes at root of an artery during laparoscopic-assisted colectomy. A circumumbilical skin incision is made and a wound protector applied. The vessels can be dissected under direct view through the small wound because the root of the colon vessel is located near the umbilicus. This technique saves operation time and cost during laparoscopic hemostasis and lymph node dissection

Several studies comparing postoperative changes of stress hormones and cytokines indicated the superiority of laparoscopic colectomy to conventional open surgery associated with surgical stress.[47–49] The difference in the systemic cytokine response may have implications for the long-term survival after a laparoscopic operation.[50]

Early gastric cancer

Early gastric cancer is defined histologically when the lesion is confined to the mucosa and submucosa. Early gastric cancer is diagnosed much more frequently in Western countries and in Japan because of mass screening and endoscopic examination. Recently, the percentage of mucosal- or submucosal-invading cancer has amounted to more than half of the total cases requiring surgical or endoscopical treatment in Japan.[8] In view of this situation, the endoscopic treatment of early gastric cancer has become increasingly popular as an alternative to surgical procedures in the hope of providing improved quality of life. Both aspiration mucosectomy and strip biopsy are useful variants for removing flat lesions measuring less than 30 mm in maximal diameter.[51] The advantage of the technique in endoscopic treatments with cutting devices enabled en bloc resection of larger mucosal lesions.[52–56] Recently, we also developed a novel technique of double endoscopic intraluminal operation (DEILO), which enables the resection of mucosal lesions by using two fine endoscopes and monopolar shears.[57] Ohgami et al. presented a lesion-lifting method for lesions of the anterior wall, the

lesser curvature, and the greater curvature of the stomach as a method of full-thickness gastric wall resection under laparoscopic procedure.[58] For lesions located in the posterior wall of the stomach, an intragastric operation in which the laparoscopic port is directly inserted into the stomach has been attempted.[59–60] In this procedure, all three trocars are placed in the gastric lumen, penetrating both the abdominal and stomach walls so that the laparoscopic removal of gastric lesions can be performed with laparoscopic instruments and laparoscopic monitoring.

These developments in the endoscopic technique have enabled endoscopists to treat large mucosal lesions. However, lesions with submucosal invasion are still contraindicated for these local treatments because 15% of case with submucosal involvement have regional lymph node metastasis. Laparoscopic-assisted gastrectomy with lymph node dissection is available for early gastric cancer with submucosal invasion, in which an endoscopic mucosal resection is not indicated. For cancer residue after endoscopic treatment, laparoscopic gastrectomy is a valued treatment. A survey conducted by the Japan Society for Endoscopic Surgery showed that 2600 laparos£opic-assisted gastrectomies were performed between 1991 and 2001 in departments of endoscopic surgery in Japan and that the number of operations continues to increase every year.[61] A randomized control study indicated that laparoscopic-assisted gastrectomy with lymphadenectomy is now a safe and feasible treatment for early gastric cancer with submucosal invasion when diagnosed by endoscopic sonography. Follow-up data after laparoscopic-assisted gastrectomy indicated a more rapid recovery of gastrointestinal motor function and shorter hospital stay compared with the conventional distal gastrectomy during the early postoperative period.[62] A longer follow-up study on postoperative quality of life has been reported.[63] This study showed that body weight 2 years after laparoscopic gastrectomy was about 100% of the preillness weight, but no further weight gain was encountered after open gastrectomy. Another long follow-up study indicated that curability after gastrectomy for early gastric cancer is not imparied by using the laparoscopic procedure.[64]

Function-preserving modulation of gastrectomy for early gastric cancer has been achieved, such as pylorus-preserving or vagus nerve-preserving gastrectomy.[65–67] The same procedures have also been attempted by using the laparoscopic procedure.[68–70] Further studies are required to determine whether these alternatives are essential for the improvement of postoperative quality of life.

Advanced-stage gastric cancer

Guidelines of treatments for gastric cancer propose D2 lymph node dissection for advanced cases (muscular involvement) are based on data of lymph node deposits accumulated by the Japan Gastric Cancer Association.[71] A laparoscopic gastrectomy with D2 dissection is performed in a limited number of institutes.[72,73] However, few reports of laparoscopic gastrectomy for advanced gastric cancer are available.[74,75] There have been no prospective trials to investigate the feasibility of laparoscopic procedures for advanced gastric cancer. The role of laparoscopic gastrectomy in the treatment of advanced gastric cancer remains to be defined. The indication for advanced cancer should be defined more strictly in gastric cancer than in colorectal cancer because of the potential higher incidence of lymph node metastasis and peritoneal dissemination in gastric cancer than in colorectal cancer.

Drawbacks of the laparoscopic GI operation and possible solutions

Port-site recurrence after laparoscopic surgery for malignancy

Port-site recurrence is a particular type of abdominal wall metastasis that occurs at the wound of the surgical port after laparoscopic surgery for malignancy. This type of metastasis is frequently associated with peritoneal dissemination and is often untreatable and uniformly fatal. Many cases have been reported since 1993,[76] and an incidence of up to 21% was initially reported. After colectomy with the conventional open procedure, abdominal wall recurrence is very rare. Therefore, post-site recurrence after laparoscopic operation is an emerging and serious problem. Actually, the application of laparoscopic techniques to the curative resection of colorectal cancer is still controversial owing to reports of this type of cancer recurrence.[77] However, the actual rate of port-site metastasis is much lower (1%) than initially reported.[78] Recently, Shoup et al.[79] reported that port-site implantation occurred in 13 (0.79%) of 1650 diagnostic laparoscopies, with a median time to recurrence of 8.2 months, and that there was no significant difference in the incidence compared with that in open incision site recurrence (0.86%). In a series of randomized control studies of laparoscopic operations and conventional procedures for colon cancer, long-term observations showed that incidence of port-site recurrence was as low as 0.6%.[44] Although the definitive causes of port-site recurrence are still unknown, extensive research using animal models[80] has shown that direct contamination between cancer cells and laparoscopic instruments during the operation is one of

the causes. Careful surgical techniques to prevent cancer cells from spreading during the laparoscopic procedure are desirable for laparoscopic surgery for malignant disease, especially in the case of serosal involvement of cancer and positive lymph nodal metastasis. It is possible that the gasless procedure may prevent this type of metastasis.[16]

As a treatment for this recurrence after laparoscopic colostomy, intraperitoneal chemotherapy has been reported with 1.5 years disease-free survival.[81] Patients were treated by surgical resection of recurrent disease combined with heated intraoperative intraperitoneal mitomycin C chemotherapy and 5 days of early postoperative intraperitoneal 5-fluorouracil.

Shorter hospital stay

One of the advantages of the laparoscopic operation is rapid patient recovery, which shortens hospital stays. Several studies were performed including patients undergoing laparoscopic cholecystectomy, and ambulatory laparoscopic cholecystectomy operation on an outpatient basis was reported to be feasible.[82–84] The cost-effectiveness of conducting these operations on an outpatient basis was demonstrated by Rosen et al.[85] They showed that the average hospital costs were significantly lower in the outpatient group compared with an observation group with an overnight hospital stay after the operation.

The effect of the shorter hospital stay compared with that required for open surgery has been observed for the case of GI laparoscopic operations for colon disease[86] and gastric cancer.[63] However, laparoscopic surgery on an outpatient basis is impossible in laparoscopic operations for patients with GI disease because it takes several days for recovery from postoperative ileus.[87] Postoperative ileus has traditionally been accepted as a physiological response to abdominal surgery and other tissue injuries. Clinically, postoperative ileus is characterized by bowel distension, lack of bowel sounds, and lack of passage of flatus and stool. Symptoms include nausea, vomiting, and stomach cramps; ileus is thus a major contributory factor to postoperative discomfort. Resumption of a regular diet is delayed, and hospital stays are prolonged. The paralytic state, on average, lasts 24 h in the small intestine and 48–72 h in the large intestine. An effective method of reducing ileus is reported to be thoracic epidural blockade with a local anesthetic. Nonsteroidal antiinflammatory agents, intraperitoneal lidocaine, and cisapride also reduce ileus, as does laparoscopic surgery.[88] An analogue of motilin, erythromycin, has proven to be beneficial for postoperative bowel motility.[89] A trial of early enteral feeding after a colonic laparoscopic operation showed that 20% of the patients could not tolerate drinking water so soon after an operation[90] and that the effect of early feeding remains unclear.

We reported a unique and effective method, i.e., gum chewing after laparoscopic colectomy to reduce physiological bowel rest after operation.[91] A total of 19 patients who underwent an elective laparoscopic colectomy for colorectal cancer participated. Each patient was randomly assigned to a gum-chewing group or a control group. The patients in the gum-chewing group chewed gum three times a day from the first postoperative morning until oral intake. As a result, the first passage of flatus was seen, on the average, on postoperative day 2.1 in the gum-chewing group and on day 3.2 in the control group. The first defecation was 2.7 days sooner in the gum-chewing group than in the control group (Table 1). All patients tolerated gum chewing on the first operative morning. Gum chewing aids early recovery from postoperative ileus and is an inexpensive and physiological method for stimulating bowel motility. This application might contribute to shorter hospital stays after a laparoscopic GI operation. However, unlike cholecystectomy, laparoscopic GI surgery on an outpatient basis remains impossible due to physiological ileus after the operation.

Long operation time and high cost

Although a laparoscopic operation for GI malignancy is feasible in selected cases, the number of patients treated with this type of operation has not dramatically increased, unlike that of patients being treated with a laparoscopic cholecystectomy. One of the obstacles to the popularization of this operation for malignancy may be the longer operation time and high cost of the laparoscopic operation for GI malignancy. The parts of the operation that require the longest time are careful lymph node dissection and secure ligation of the blood supply. Many devices have been developed for dissection and hemostasis.[3,4,6]

In GI laparoscopic surgery for malignant disease, the resected specimen should be removed ex vivo, and a subsequent wound is required for this purpose. Non-

Table 1. Effects of gum chewing on recovery from postoperative ileus following laparoscopic colectomy

		Days following operation	
	n	First flatus	Defecation
Control group	9	3.2 ± 0.9	5.8 ± 2.2
Gum-chewing group	10	2.1 ± 0.5*	3.1 ± 1.1*

Mean ± SD (range)
*$P < 0.01$, vs control group
Source: Modified from Ref. 91

neoplastic tissue, such as the spleen, can be minced in a plastic bag in the abdominal cavity to be then extracted through the skin incision after removal of the laparoscopic port; however, tissues with malignancy should be removed ex vivo while carefully avoiding the spillage of cancer cells. We invented an efficient usage of the circumumbilical incision for removal of specimens and proposed the simplified ligation of vessels and lymph node dissection under direct view through the incision during laparoscopic-assisted colectomy (Fig. 2). This incision provided a sufficient wound for removal of the specimen while maintaining good cosmetic results. Using this method, the operation time was as short as that required for the conventional colectomy. Additionally, the cost for the operation decreased to the level of that for laparoscopic cholecystectomy.

Training for GI laparoscopic surgery

In a multicentral prospective study with 1658 patients, Marusch et al. reported that conversion to open surgery was significantly less frequent in a group of surgeons with experience of more than 100 laparoscopic colorectal operations than in a group of surgeons with experience of fewer than 100 cases. The duration of the procedures performed by the more experienced group of surgeons was appreciably shorter than that in institutions with a smaller frequency of such operations.[92] They concluded that the learning curve for colorectal procedures is longer than that for the equivalent open surgery and for other laparoscopic operations. The GI laparoscopic procedure required longer training than other laparoscopic operations, probably because of its demand of advanced techniques, such as ligature and suturing. In another report, the cutoff point for early and late experience was set at 30 cases in the colonic laparoscopic surgery.[93] However, laparoscopic procedures had not been developed when the surgeons in theses multicentral studies trained in the course of their residency. They were trained to correlate visual impressions with direct tactile feedback on the basis of conventional operation methods. The current generation of surgeons may have a heightened two-dimensional sense and better skills at manipulating instruments with their fingers as a result of having grown up in the videogame era. Additionally, current surgeons might have the opportunity to encounter laparoscopic procedures in medical school. There is an interesting report about laparoscopic skill training.[94] Second-year medical students and second- and third-year surgery residents followed a curriculum that included five video-trainer tasks. The improvement in their laparoscopic skill was evaluated by a final test after training for 10 days. The results demonstrated that the adjusted improvement was significantly larger for the group of medical students than for the group of surgery residents. Training for laparoscopic procedures should be included not only in the surgical residency program but also in the educational program for medical students. A change in the curriculum for surgical education is desired to help prepare the pioneers of the future in the field of laparoscopic surgery.

Recently, advanced computer technologies have created new educational tools using virtual reality.[95] The training system and evaluation of laparoscopic skills will develop with a change in the curriculum of surgical education.

Application of robotic techniques in laparoscopic operations

The telerobotic Zeus and da Vinci surgical systems replace the surgeon's hands with robotic instruments and serve as a master–slave relationship for the surgeon. In a prospective trial, laparoscopic cholecystectomy using a computer-assisted system was reported to be safe and feasible with operating times and patient recovery times similar to those with conventional laparoscopy. The same advantages of telerobotic surgery have been reported in the field of GI laparoscopic surgery.[96] In the future, the computer-assisted procedure may permit easier and safer anastomosis, ligatures, and dissection of lymph nodes in the laparoscopic operation for GI malignancy. However, this technology is still expensive and time-consuming for setup to use it as routine procedure, and there are no apparent advantages for the patient at present. A simple, cheap, and convenient robotic system is desired.

Conclusion

Within the last decade, laparoscopic surgery has expanded to the treatment of GI malignant disease, and many studies have confirmed the feasibility and safety of the laparoscopic procedure. Oncological results also support its effectiveness as a treatment modality. The indication of these surgical procedures continues to expand; however, the drawback of the laparoscopic application for advanced GI malignancy still remains. An additional solution to these drawbacks is desired for the safe and effective contribution of laparoscopic surgery in GI malignancy.

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