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EDITORIAL UPDATE

Laparoscopic Surgery—15 Years After Clinical Introduction

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The introduction of laparoscopic surgery into clinical routine more than 15 years ago has dramatically changed the field of surgery. An abundance of case studies, randomized controlled trials and several carefully performed meta-analyses have demonstrated the advantages of this new technique on the highest level of evidence-based medicine. Patients undergoing laparoscopic operations have less postoperative pain, less impairment of vital functions, a shorter hospital stay and they resume usual activities more rapidly.

In the review by Soper *et al.*[1] published 10 years ago, only diagnostic laparoscopy and cholesystectomy were defined as procedures generally accepted for laparoscopic surgery. In the meantime, this spectrum has expanded considerably, in part as a result of the many studies published over the years. Even though laparoscopy is said to be the third patient-friendly revolution in medicine following the introduction of asepsis and anaesthesia, its further integration into the daily routine is sluggish. Therefore, the question today is not in terms of what is accepted and what is not accepted, but rather, why scientifically founded advantages are either not, or only very slowly, incorporated into daily routine. The reasons are manifold.

Laparoscopic surgery is considered difficult. It is a completely novel technique that must be learned by even the most experienced conventional surgeon. The instruments and optic field are different, the surgeon works indirectly and tactile sensations are greatly reduced. The operating field is shown on a more or less distant monitor, leading to changes in the axis between head, arm, eye and operating field. The surgeon must develop new strategies to compensate for the two-dimensionality and resulting loss of depth perception. These difficulties are exacerbated by the fact that the surgeon has no direct control over the field of vision since the camera is directed by the assistant, who functions as the eye of the surgeon. The camera assistant either alleviates or aggravates the procedure depending on the amount of experience he or she has, especially in terms of ability to hold the camera steadily. The long and rigid instruments require greater agility. Conventional surgery offers seven degrees of freedom, whereas laparoscopic surgery provides only four.[2] This loss of freedom increases the difficulty in suturing and tying knots.

Considering these difficulties, especially in mastering the ''video-eye-hand'' coordination,[1] it is not surprising that laparoscopic surgery has a substantial learning curve. It demands time, patience, mental strength and persistence. Many have attempted this new technique but only a few have integrated it into their daily routine, with the exception of cholecystectomy. This is especially true for the most important teaching centres, the academic medical centres. Traditionally, open surgery is preferred, and time restraints hamper aquiring skills associated with a strenuous learning curve. In addition, the emphasis in these hospitals on organ transplants and difficult oncological surgery results in a lack of so-called ''easy procedures'' such as cholecystectomy, appendectomy, hernia repair and uncomplicated colonic surgery.

The last, but not unimportant reason concerns costs. Patient advantages are counterbalanced by high expenditure for equipment, longer operating times and use of more material, which all increase cost. The reimbursement system generally does not take this into account. As with all areas of medicine, the issue of the expense of laparoscopic surgery is increasingly important, especially when it is compared with traditional, open operations. The direct cost per se (operation) may not reflect the main benefit of laparoscopic surgery. Rather, laparoscopy decreases

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indirect cost to society by returning patients to the work force more rapidly.[1] However, it is difficult to convince insurance companies to pay higher hospital costs for the benefit of society.

This article reviews the current position of laparoscopic techniques for the most frequently performed procedures in visceral surgery, with an emphasis on the personal experience of the author and his team.

INGUINAL HERNIA REPAIR

The first attempts at repairing inguinal hernias laparoscopically were made by gynecologists in the 1980s.[3,4] Arregui[5] and McKernan[6] described the main features of transabdominal preperitoneal patch plasty (TAPP) and total extraperitoneal patch plasty (TEP) in the early 1990s. Initial mistakes caused by inadequate anatomical knowledge, too many or incorrectly placed clips and especially undersized patches have been corrected. Therefore, both methods can be used effectively and efficiently. In accordance with Pascal's physical principle, the objective of both operations is to cover the entire myopectinal opening with a large, biocompatible, synthetic mesh.

The TAPP technique was begun in my hospital in 1993. High patient satisfaction led to a sharp increase in the number of operations performed in the years thereafter. Since 1997, more than 1,000 patients undergo laparoscopic inguinal hernia repair annually at our hospital.[7] The most recent description of our technique is found in "Laparoscopic Hernia Surgery", edited by Karl Leblanc.[8]

From 1993 until today, my colleagues and I have performed 11,570 inguinal hernia repairs using the TAPP technique. The median operating time averages 40 minutes, the morbidity rate is 2.9%, the recurrence rate is 0.67% and the median time to return to work is 14 days.[7] The increasing safety of this technique has led to broadening of its usage, and now includes all patient populations and all types of hernias. Therefore, our patient population is completely unselected. Patients of all ages (the oldest was 103 years) and all weights (the heaviest was 178 kg) are included, as well as the most complicated and challenging hernias, *e.g.* inguinoscrotal hernias. All patient information is documented prospectively and integrated into a follow-up program. Ninety-three percent of the patients were seen at least once during follow-up. Disadvantages of the laparoscopic technique compared with conventional surgery include the higher operating room costs and the need for general anesthesia. Although open (anterior) hernioplasty with mesh implantation according to Lichtenstein can be performed cost-effectively in an out-patient setting with local anesthetics, long-term results from recent studies report chronic pain in up to 28% of patients.[9,10] Because recurrence rates after mesh reinforcement have been shown to be significantly lower than for suture repair,[11] a major objective in hernia surgery has shifted from preventing recurrence toward preventing chronic pain. In our experience with TAPP, only 4 patients needed surgical therapy due to chronic pain. Until now, no mesh has had to be removed because of chronic pain. The recently published, most extensive meta-analysis of all randomized trials to date found significant advantages in terms of all pain-related parameters for patients who underwent laparoscopic/endoscopic preperitoneal patch repairs compared with anterior patch repair.[12] It is remarkable that in contrast to the older meta-analysis by the EU-Trialist Cooperation,[11] the recent, much more extensive studies do not show a higher risk of severe intraabdominal injuries (intestinal, blood vessels, bladder) compared with open surgery. Furthermore, no difference was found between the two techniques in terms of recurrence rate. One randomized trial found a recurrence rate twice as high for laparoscopic repair compared with conventional open patch plasty.[13] However, critical evaluation of this study reveals the reality of Veterans Administration Hospitals. The entrance criterium for the participating surgeon was set at a mere 25 previous hernia repairs. In the course of the study, a single participating surgeon averaged only three operations per year. It must be assumed that the poor outcome is a reflection of considerable training deficits. In addition, the required minimum patch size of 10×15 cm was not adhered to.

Detailed analysis of the results from the VAH study confirms that recurrence rates do not differ between laparoscopic and open repair, given sufficient surgical experience and adequate patch size. However, according to the VAH study, the learning curve should include at least 250 hernia repairs. In contrast, analysis of data including all surgeons in my department,[14] even the trainees (n = 20), shows a correlation merely between the amount of operations performed and the operating time. There was no difference in morbidity and recurrence rates between the low-volume and high-volume surgeons, providing there is strict standardization of operative technique and well-structured training (Table 1).

CHOLECYSTECTOMY

More than 100 years after the first cholecystectomy by Langenbuch,[15] the first laparoscopic removal of a gall-

Table 1.
Laparoscopic hernia repair (TAPP)

Results of low/high volume surgeons				
Surgeon [Nr.]	Hernias [n]	Op-time [min]	Morbidity [%]	Rec.-rate [%]
1	4733	38	2.6	0.76
2	2159	40	3.7	0.7
3	1324	40	3.5	0.91
4	933	40	2.1	0.83
5	830	40	1.9	0.14
6	671	50	2.5	0.36
7	524	45	0.9	0.3
8	335	45	2.1	–
9	213	50	1.9	0.46
10	170	50	1.8	0.58
11	152	55	1.3	–
12	108	55	3.7	–
13	96	50	–	–
14	72	50	–	–
15	44	60	4.5	–
16	23	45	–	–
17	21	65	–	–
18	21	64	–	–
19	6	67	–	–
20	2	72	–	–

bladder was performed in 1985 by Mühe.[16] In 1987, Mouret[17] performed a laparoscopic cholecystectomy with establishment of pneumoperitoneum for the first time. Since then, rapid development of this procedure has made laparoscopic cholecystectomy the gold standard for surgical treatment of gallbladder stone disease.[18] Numerous randomized controlled trials have shown significant advantages of the minimally invasive over the conventional technique. Patients have less pain,[19–25] less restriction in pulmonary function,[21,22,24] fewer complications,[26] a shorter length of hospital stay,[19,21,24,26,27] shorter time to return to work,[19–23,28] fewer incisional hernias[29] and higher quality of life.[26] In addition, a recently published randomized trial which evaluated socioeconomic factors found the shorter time off work compensated for the well-known higher operation costs.[30] Perhaps most importantly, minimal access with four small incisions makes this technique especially attractive to patients. Cholecystectomy is the ideal domain for minimal invasive surgery. The conventional approach causes an inordinately large access trauma compared to the relatively small intraabdominal surgical trauma. In the laparoscopic approach, access trauma and intraabdominal surgical trauma coincide. Despite these advantages, surveys show that only 70% of all gallbladders are removed laparoscopically, and the conversion rate is approximately 7%.[31,32] The reasons for this disparity between the many proven advantages and the relatively low rate of acceptance have been discussed extensively in the introduction. Here, too, the necessity of aquiring a completely new technique plays a critical role. Again, strict standardization and structured training are essential for success.

Analysis of our patient population, including over 7,000 cholecystectomies, shows the figures that can be achieved.[18] We have a median operating time of 51 minutes, a morbidity rate of 2.9% and conversion was necessary in only 70 cases (1%). The mortality rate was 0.03%. A total of 31 surgeons performed the cholecystectomies. Only 58 (1.7%) patients underwent primary conventional cholecystectomy from 1999 to 2004. In 23 cases, the conventional approach was chosen because of common bile duct stones which could not be treated endoscopically. Fifteen patients had abdominal adhesions following previous operations, *e.g.* gastric resection. During the same period (1999–2004), conversion was necessary in only 7 (0.2%) cases, whereas it was necessary in 32 (2.2%) cases in the first observation period (1991–1994).

Injury of the common bile duct is considered the most dangerous complication of laparoscopic cholecystectomy. An early publication[33] showed a distinctly higher percentage of this perilous complication for laparoscopic surgery, while a later study[34] showed no difference with increasing competence of the surgeon (0.27% *vs.* 0.17%). Our figures corroborate this. During the first observation period (1991–1994), injuries to the common bile duct occurred in 0.34% of the cases. This figure has not exceeded 0.1% in the last 10 years.[18]

Laparoscopic cholecystectomy still presents particular problems for acute cholecystitis. One recent publication reports astoundingly different success rates, varying from 30% to 75% for 26 different hospitals, apparently depending on the surgeon's experience.[35] Moreover, a Swiss study of quality control shows that the conversion rate increases from 3.6% in uncomplicated gallbladder disease to 19.5% in acute cholecystitis.[36] This, as well as the data from our own hospital, indicates that success is strictly related to experience.[18] Our results show that nearly the same level of success can be achieved in acute cholecystitis as with non-complicated gallbladder disease. Admittedly, the learning curve was steeper, so that in 1993 only 62% of patients with acute cholecystitis were treated laparoscopically, in contrast to 87.5% of patients with non-complicated gallbladder disease (Fig. 1).

The morbidity rate was merely 2.5% and the conversion rate 0.5% for the last 800 operations performed between

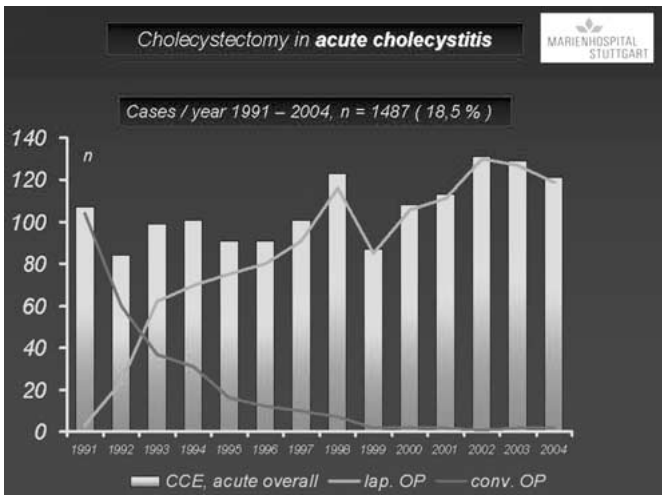

Figure 1.

1996 and 2005. The low rate of general complications (*e.g.* pneumonia, cardiac complications) of only 0.73% is remarkable. This rate often exceeds 30% in conventional surgery of acute cholecystitis.[37] These results emphasize the superiority of the laparoscopic approach. However, it is important to note that surgery should be performed as quickly as possible following onset of symptoms, as our experience has shown us and as randomized trials have confirmed.[38–41] The sooner the operation is performed, the lower the rates of conversion and morbidity. In addition, a significantly shorter hospital stay helps to lower health care costs.

Cholecystectomy is the first and, so far, the only operation in which laparoscopy is recognized as the gold standard worldwide. Despite almost 20 years of clinical experience and countless randomized trials showing its superiority over conventional cholecystectomy, only two thirds of all gallbladders are successfully removed laparoscopically.

Training, furnishing with credentials and granting priveledges to surgeons to perform laparoscopic operations remain hotly debated issues.[1] We agree completely with Soper *et al.* who postulate that since hospitals have been the final arbiters in deciding which surgeon can perform specific procedures, they must insist on minimal criteria for training and furnishing credentials to their surgeons, such as the criteria suggested by the Society of the American Gastrointestinal Endoscopic Surgeons or the German Association for Minimal Invasive Surgery.

COLORECTAL SURGERY

The feasibility of laparoscopic colon resection was demonstrated as early as 1991.[42–44] One year later, abdominoperineal rectum resection for rectal carcinoma was shown to be possible.[45,46] Again 1 year later, the first study was published in which results of laparoscopic anterior resection were compared with conventional surgery in a small number of patients with rectal carcinoma.[47] The first publications on total excision of the mesorectum for carcinoma (TME) of the middle to lower third of the rectum were reported at the start of this century.[48–50] Conclusively, laparoscopic colon or rectum resection is feasible, provided the surgeon has appropriate experience and the patients have been properly selected.

Almost every publication on laparoscopic colorectal procedures confirms the advantages for the patient. These include less pain, which enables rapid mobilisation, less impairment of pulmonary function, which leads to lower rates of pneumonia, and more rapid recovery of intestinal function, which leads to more rapid nutritional recovery. In addition, laparoscopy is associated with less surgical trauma, higher quality of life and fewer problems with wounds and scars. Twelve randomized controlled trials meeting the requirements of evidence-based medicine assessed the short-term outcome following laparoscopic resection for colorectal cancer. All of these trials confirmed the advantages of laparoscopy.[51] The evaluation of more than 2,500 patients showed a significant reduction in morbidity rate for patients treated laparoscopically. Our results for patients undergoing sigmoidectomy for diverticulitis corroborate these findings (Table 2). We also found a significantly lower morbidity rate in the laparoscopic group. The results of conventional surgery were published several years ago.[52] The length of the resected segment was almost identical in the laparoscopic and conventional groups, which indicates that both techniques ensure adequate resection length. It could be contended that selection bias caused our favourable results for the laparoscopic group. Indeed, Fig. 2 does show an initial patient selection bias. However, presently over 90% of all patients with sigmoid diverticulitis are operated on laparoscopically. Also, when the results are analysed according to severity using a modification of the Hinchey Classification,[52] consistent advantages for laparoscopy at every stage of diverticulitis can be found.[53]

In summary, the highest scientific level (EBM-Level 1a, recommendation A) has demonstrated clear advantages of laparoscopy over conventional surgery, at least with respect to short-term outcome. However, these advantages cannot necessarily be applied to malignant colorectal disease because in the case of malignancy, long-term results are extremely important. First it must

Table 2.
Laparoscopic Sigmoidectomy for Diverticulitis

Results compared to conventional surgery		
	Conventional (Suture by hand) n = 445*	Laparoscopic (Double stapling) n = 502
Operative time [min]	127	163
Morbidity [%]	26.5	15.9**
Letality [%]	1.6	0
Specimen length (fixed) [cm]	19.4	22.3
Hospital stay [days]	19.1	12.6

*C.G. Schmedt *et al.*, Chirurg 71; 2000.
**$P < 0.01$.

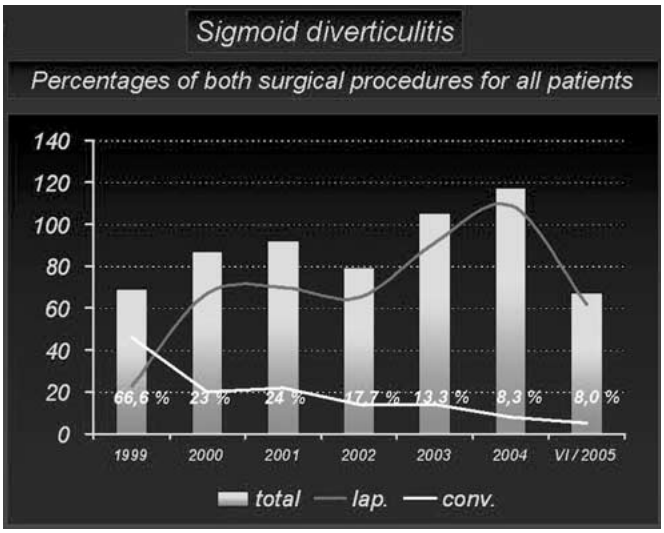

Figure 2.

be established that pneumoperitoneum is not detrimental, and more importantly, that laparoscopy does not violate the principles of radicality. In the early 1990s, a number of reports were made on the increased incidence of port-site metastases, which are metastases in the abdominal wall at the previous trocar incision sites associated with the establishment of pneumoperitoneum.[54] These reports must be taken seriously. Many clinical and experimental studies were then conducted to explain this phenomenon. Interestingly, a dramatic reduction in port-site metastases was found with increasing experience of the surgeon. A current survey of the literature by 16 authors with a total of 1,737 laparoscopically performed colorectal resections for carcinoma found port-site metastasis in only 17 (1%) cases.[55] This is identical to the frequency of wound metastasis in conventional surgery. Therefore, it is thought that port-site metastases may not hinder laparoscopic colectomy, but instead that they are an unfortunate sequela of inexperienced surgeons.[55]

The second, most important question in laparoscopic colorectal surgery concerns oncological radicality. Franklin *et al.*[56] were the first to show that laparoscopic colectomy for malignancy was as good as or superior to open surgery in terms of length of specimen, safety margins and number of lymph nodes retrieved. A recently published meta-analysis of 35 studies with more than 3,935 patients came to the same conclusion.[57] Therefore, we can assume (IBM Level 1a, recommendation A) that laparoscopy can ensure adequate oncological resection. Laparoscopy may even provide important advantages. One of these is the magnifying effect of the optics which may help prevent nerve damage, for instance of the hypogastric plexus. Another is the fact that the dissection instruments (ultrasound) enables more precise surgery with less blood loss.

However, even if the criteria for oncological radicality are fulfilled in terms of safety margins and number of lymph nodes, reliable information concerning long-term results is essential. This information is not available yet. It was not until 2000 that Franklin *et al.* demonstrated that the 5-year survival rate for both laparoscopic and conventional resection for stage 3 colon cancer was identical.[58] Only 2 years later, Lacy *et al.*[59] showed in a randomized controlled trial that laparoscopically assisted colectomy is more effective than open colectomy for treating colon cancer in terms of morbidity, hospital stay, tumour recurrence and cancer-related survival (EBM Level Ib, recommendation A). The results of a large, randomized controlled multicentre study, the Cost Study, has just been published and is particularly significant in this context.[60] Eight hundred and Sixty-three patients were evaluated with a mean follow-up of 4.4 years. It was found that the length of resected colon, number of lymph nodes and also the long-term oncological results were similar (EBM Level b, recommendation A). Leung *et al.*[61] reported almost identical results in their large, prospective, randomized single-centre study.

Information on rectal carcinoma is lacking. To date, there are no Level 1a studies and only five 1b studies, three of which deal mostly with specific problems. One reason is that laparoscopic surgery for rectal carcinoma is much more difficult than for colon carcinoma. The feasibility of laparoscopic abdominoperineal resection, anterior resection and TME for rectal carcinoma have been demonstrated in animal studies[48,62] and in numerous clinical trials.[45,46,49,50,63–78] Laparoscopic surgical treatment of rectal cancer does not seem to have any oncological disadvantages (EBM Level III). One advantage is

mentioned by Pikarsky and Wexner, who state that "laparoscopy allows excellent exposure particularly deep in the pelvis which may allow the surgeon to perform a more meticulous dissection under direct vision".[79]

A total of 13 comparative studies (EBM Level IIb) also came to the conclusion that oncologic radicality is the same for laparoscopic and conventional surgery. The morbidity rate is also similar, although patients recover more rapidly following laparoscopic procedures. The operating time was consistently between 10 and 80 minutes longer for laparoscopy. One disadvantage of all these studies is their comparatively small number of patients, namely between 10 and 30 patients.[47,80–91]

Five other non-randomized trials, but with EBM Level 2a, come to similar conclusions.[92–96] These studies found no significant difference in oncological criteria, morbidity rate or recovery time. The operating time was 40–50 minutes longer for laparoscopy. However, the groups had only 20–40 patients each. To date, there are only five randomized controlled trials (EBM Level Ib) that have compared laparoscopic resection or amputation with conventional surgery.[97–101] Only two of these studies analysed morbidity, recovery time and short-term oncologic results.[100,101] Both RCTs concluded that laparoscopic rectum amputation and TME have similar results compared with conventional surgery, although blood loss was significantly lower and recovery time was shorter for laparoscopic TME.

GASTROESOPHAGEAL REFLUX DISEASE

The first laparoscopic Nissen fundoplication was performed in 1991 by Dallemagne.[102] This minimally invasive technique revived the surgical treatment of GERD and competes with conservative therapy. Mahon *et al.*[103] were the first to compare laparoscopic surgery with "optimal medical therapy". They found that laparoscopic Nissen fundoplication results in significantly less acid exposure to the lower esophagus at 3 months, and significantly greater improvements in both gastrointestinal and general well-being after 12 months compared with PPI treatment.

With the renaissance of surgical treatment, we encounter a number of questions in connection with treating GERD. Is laparoscopy truly superior? Is the partial fundoplication (90°, 270°) equivalent to, or maybe even superior to the 360° wrap? Can an improvement in quality of life be reached for GERD patients by laparoscopic Nissen fundoplication? How important is hiatoplasty, and is reinforcement with a mesh in addition to hiatoplasty necessary for large hiatal hernias? Is a "short esophagus" clinically significant and does it change the therapeutic procedure? Should the surgical management of paraesophageal hernia also include fundoplication? Can laparoscopic fundoplication prevent the progression to Barrett's esophagus? And lastly, what are the costs of surgical therapy compared with proton pump inhibitors?

Fuchs analysed several large prospective studies and six randomized trials[104–110] that compared open with laparoscopic fundoplication.[111] He came to the conclusion that the laparoscopic method leads to a significant reduction in perioperative morbidity rate, postoperative hospital stay and compromise in the immune system. The functional outcome is similar for both procedures when they are performed in a centre of excellence. Good, to very good results can be expected in 85%–90% of the cases. Recurrent reflux disease occurs in 4%–5% of the cases and the learning curve entails at least 50 operations.[112]

One study found a lower incidence of side effects and slightly greater risk of recurrence of reflux symptoms following anterior 180° and anterior 90° partial fundoplication compared with the traditional 360° wrap.[113,114] Excluding this study, all other randomized trials have not found a difference in success rate between the different laparoscopic techniques.[115–119] However, Nissen patients tend to have more problems with "gas bloat" flatulence.[111] Nevertheless, several carefully conducted studies have shown a significant improvement in quality of life for GERD patients following Nissen fundoplication.[120–122] In a recently published study, Dallemagne *et al.*[123] found that most patients who had an improved quality of life and no need for daily acid suppression 5 years postoperatively also did so 10 years postoperatively.

The question is frequently raised concerning the optimal method of hiatal closure to prevent postoperative intrathoracic wrap migration. As early as 1996, all experts at a concensus conference of the E.A.E.S. generally agreed that posterior crural closure is necessary and that non-absorbable suture material should be used.[124] Sufficient hiatal closure is of great importance for the success of antireflux surgery. The most common reason for reoperation of recurrent hiatal hernia after primary antireflux surgery is due to failure of the hiatal closure with intrathoracic wrap herniation.[125,126] To reduce the postoperative incidence of this complication, a number of groups have advocated the use of prosthetic materials for hiatal reinforcement. Two prospective, randomized controlled trials compared the recurrence rates of laparoscopic Nissen fundoplication with prosthetic cruroplasty versus laparoscopic Nissen fundoplication with simple sutured crural closure.[127,128] Both authors found a

reduction in recurrence rate for prosthetic cruroplasty, namely from 22% to 0%[127] and 26% to 8%.[128] Champignon and McKernan[129] postulate a correlation between the size of the hernial defect and the recurrence rate. They conclude that a prosthetic hiatal closure is recommended for defects larger than 5 cm. Possible esophageal erosion or migration of prosthetic material in the esophagus might be a disadvantage, although this is a point of debate.[130] Granderath *et al.*[128] found no cases of esophageal erosion among 300 patients with mesh hiatoplasty (with a follow-up greater than 90%). Their experience suggests that the correct mesh placement plays a crucial role, *i.e.* the mesh should not come into contact with the posterior portion of the esophagus.

There is no doubt that hiatoplasty plays a central role in the treatment of paraesphageal hernia.[131,132] In this case, hiatal closure is essential, and the necessity for fundoplication has been questioned repeatedly. However, several authors have shown a higher rate of postoperative reflux symptoms when fundoplication is not performed.[133–135]

Some authors have stressed the importance of the ''short esophagus'' as a reason for recurrence, and have suggested liberal use of a Collis type gastroplasty. But the experience of Aly *et al.*[132] and others[136,137] does not support this. Adequate esophageal mobilistion is facilitated by complete reduction of the hernial sac from the mediastinum, which seems to be important for successful laparoscopic repair and prevention of recurrence.

Many critics cite higher costs as an argument against laparoscopic antireflux surgery. Carefully performed cost-benefit analyses have shown that in terms of long-term results, a well functioning fundoplication is more cost-effective than drug therapy. The point at which the expense for drug therapy exceeds the surgical expense is 3–5 years.[138,139]

The question as to whether laparoscopic fundoplication can prevent Barrett's esophagus, and therefore prevent Barrett's carcinoma, cannot be answered yet. The literature indicates so far that for pre-existing Barrett's oesophagus, the progression to carcinoma cannot necessarily be prevented. However, a newer prospective randomized trial showed no cases of carcinoma and significantly less cases of Denova dysplasia for the fundoplication group compared with the drug therapy group.[140,141]

APPENDECTOMY

The first laparoscopic appendectomy was performed in 1981 by the gynecologist Kurt Semm.[142] Although a number of meta-analyses have shown advantages of laparoscopy,[143–147] the indication and outcome of this procedure is still being discussed controversially.[148] Less than half of the patients in Germany have laparoscopic appendectomies. A recently published, population-based analysis using a national administrative data base showed that laparoscopic appendectomy has more than doubled in the past 5 years at U.S. academic medical centres and teaching hospitals.[149] Analysis of more than 60,206 patients showed an increase from 20% in 1999 to 43% in 2003. In agreement with the aforementioned meta-analysis, the population-based study found laparoscopic appendectomy to be associated with a shorter hospital stay and lower complication and 30-day readmission rates. In contrast to the meta-analysis cited above, the population-based study found no significant difference in the rate of intraabdominal infection. In addition, there was no difference between the observed and expected in-patient mortality between laparoscopic and open appendectomy. Interestingly, the authors found the mean cost for laparoscopic appendectomy to be similar to that of open appendectomy. Moore *et al.*[150] found similar results in their recently published study using a decision analytic model to evaluate these two procedures. An economic advantage for the hospital was found for open appendectomy, whereas the laparoscopic approach was more favourable for the patient.

Primary perforated appendicitis was initially considered a contraindication for laparoscopic appendectomy. Several studies refute this, showing that complicated appendicitis can also be treated successfully laparoscopically.[151–156] However, the conversion rate then increases up to 47%. Kapischke *et al.*[157] found a conversion rate of only 2.5%, indicating that the experience of the surgeon plays an important role in this discussion. Operative success in complicated appendicitis depends on the following: diligent intraabdominal lavage (especially the pouch of Douglas, subhepatic and subphrenic spaces on the right side), placement of the drain in the lowest point in Douglas's space for both drainage (Easyflow) and postoperative lavage, and safe removal of the appendix. The latter is a matter of continual discussion. Should the appendix be removed with the less expensive Röder loop or with the significantly more expensive stapler? Our experience, and that of most other authors, has shown the stapler to be the safer procedure, especially when infection has advanced to the base of the appendix and cecal pole. The stapler technique can be used to resect the cecal pole in cases of phlegmon. In addition, the stapler enables cutting the base of a retrocecally located appendix first, before anterograde appendectomy.

This can make the procedure considerably easier. Especially in difficult cases, the first step should be cecal mobilization so that the appendix and cecal pole are optimally exposed.

The critical question is whether laparoscopic appendectomy provides advantages for the patient. There is no doubt that for a slender patient with an only mildly inflamed appendix located mesocecally with a mobile cecal pole, laparoscopy does not have many advantages over a conventional mini-laparotomy of 2–3 cm. In this case, the patient will occasionally have more pain due to the pneumoperitoneum than from the small abdominal incision. On the other hand, there is no question that a muscular patient with a thick, adipose abdominal wall and highly inflamed appendix in an unfavourable position, *e.g.* located retrocecally, can benefit greatly from laparoscopy, because a mini-laparotomy incision of 3–4 cm is definitely not possible. In my opinion, the lack of conviction for laparoscopic appendectomy in the literature is due to the lack of stratification of patient characteristics and degree of infected appendix.

Another recognized advantage of laparoscopy is when the diagnosis is uncertain. Diagnostic laparoscopy can not only confirm acute appendicitis but can also provide a means of attaining a reliable differential diagnosis of, for instance, gynecological disease in young women.

Conclusively, it can be said that laparoscopic appendectomy has led to a higher level of quality for treating appendicitis. The advantages are especially apparent when the diagnosis is uncertain, for patients with an adipose or muscular abdominal wall and for patients with a highly inflammed appendix in a difficult location. Resection with a stapler seems to be superior to the Röder loop. In difficult cases, it is advisable to mobilize the cecum for better exposition of the base of the appendix. Perforated appendicitis should be treated with ample lavage, sufficient drainage of Douglas's space and, when necessary, continual postoperative lavage. However, the data following EBM criteria concerning drainage are not sufficient to make a definitive recommendation.

INCISIONAL HERNIA

Incisional hernia has been included in the repertoire of laparoscopic surgery, especially with the goal of preventing extensive trauma to the abdominal wall, which can promote postoperative wound infection, a feared complication that is not infrequently encountered. A meta-analysis of 8 randomized trials with 390 patients found a significantly lower complication rate and shorter length of hospital stay following laparoscopic surgery.[158] However, long-term controlled trials are necessary for a definitive conclusion. There are still problems to be solved concerning both cost-efficient mesh material that can come into contact with the bowels without causing problems and fixation technique. It seems the fixation with clips or tacks alone is insufficient and associated with a high recurrence rate. Fixation with transfascial, non-absorbable sutures approximately 1 cm apart seemed to have the best results. This method is, however, technically difficult and much more time consuming. Also, pain at the fixation points in the early postoperative phase is not seldom, especially when the sutures extend through the abdominal wall with external knots.

GASTRIC, PANCREAS AND LIVER SURGERY

The feasibility of laparoscopic gastric resection was first proven by Goh,[159] liver resection by Azagra[160] and pancreas resection by Gagner and Pomb.[161] Understandably, there are only few randomized, comparative clinical trials.[162] Since the data that have been published contain only small numbers of patients, comparison with conventional surgery is not possible yet. However, a number of hospitals demonstrate promising developments, in particular the advantages of robot-assisted laparoscopy during certain phases of these complicated operations.[163,164]

ADRENAL GLAND

The first laparoscopic adrenalectomy was performed by Gagner in 1992.[165] Today there is no doubt that adrenal tumours offer the ideal indication for laparoscopic surgery, provided that a certain tumour size is not exceeded. In a recently published review[166] analyzing 50 studies on laparoscopic adrenalectomy and 48 studies on open adrenalectomy, Brunt found that laparoscopic adrenalectomy resulted in fewer complications (wound, pulmonary, reduced incidence of incidental splenectomy) than was seen for open adrenalectomy. Transperitoneal and retroperitoneal laparoscopic access compete with eachother. Both techniques might have advantages over the conventional method because of less pain, faster postoperative recovery and a shorter length of hospital stay. In terms of laparoscopic/endoscopic access, one randomized controlled trial[167] found no difference

between the two in terms of operating time, analgesic consumption, complications and length of hospital stay.

CONCLUSIONS

Minimal invasive surgery offers treatment of many standardized as well as technically advanced surgical procedures. It is impossible to imagine modern surgery without laparoscopy, even in smaller hospitals. It has proven itself to be a truly patient-friendly revolution, even in daily routine. The advantages have been confirmed by countless meta-analyses, systematic reviews, randomized controlled trials and mono- and multicentred case studies on the highest level of evidence-based medicine. The advantages over conventional surgery are primarily pain reduction, shorter length of hospital stay and faster resumption of usual activities. In addition, many studies also show lower morbidity rates and less impairment of the immune system. Furthermore, minimally invasive surgery has no disadvantages for the oncological patient. Nevertheless, there are critical voices that must be taken seriously. For the most part, the critics cite technical difficulties and the associated longer training as arguments against laparoscopy. Another argument is the higher costs because of the (usually) longer operating times and necessity for new instruments which are sometimes used for only one operation. There is no question that the learning process can be painful and requires patience, persistence and courage. We should not forget that even conventional surgery has taken over 100 years to reach the high standard it has today, albeit with considerable differences in quality depending on the hospital and surgeon. It was a fallacy to think the experienced surgeon could effortlessly acquire laparoscopic surgical skills, even though it is true that the good conventional surgeon should have less problems with the laparoscopic technique. But since it is, in fact, a completely new, nearly revolutionary method, the learning process is long and sometimes troublesome, even for the experienced surgeon. The future development is dependent on young surgeons becoming familiar with the method from the very beginning and, in a sense, ''growing up'' with laparoscopy. The current standing reported in this article is the momentary situation. Future developments are only partially visible.

Minimally invasive procedures have changed the field of surgery immensely. They emerged from conventional surgery, and yet they also influences open techniques retroactively, so that to the patient's advantage, surgery has reached an a extremely high standard, one unimaginable only a few years ago.

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