

Unexpected findings on laparoscopy for suspected acute appendicitis: a pro for laparoscopic appendectomy as the standard procedure for acute appendicitis

Lars Ivo Partecke · Wolfram von Bernstorff ·
Annette Karrasch · Katharina Cziupka · Anne Glitsch ·
Albrecht Stier · Claus Dieter Heidecke · Jürgen Tepel

Received: 13 September 2009 / Accepted: 19 October 2009 / Published online: 19 November 2009
© Springer-Verlag 2009

Abstract

Purpose Evaluation of the feasibility, cost-effectiveness, time of surgery, morbidities, and other/additional findings during laparoscopy for suspected appendicitis.

Methods Prospective evaluation of 148 laparoscopies for suspected acute appendicitis.

Results Laparoscopic appendectomy was safe and cost-effective. No appendiceal stump leaks or wound infections occurred. Of the patients, 4.7% developed intra-abdominal abscesses. Mean time of all procedures was 47 min: 42 min for simple appendectomies ($n=126$), 67 min for perforated appendicitis ($n=15$), and 75 min for converted procedures ($n=7$). Twenty-one of 148 (14.2%) patients had unexpected findings instead of appendicitis: inflamed epiploic appendices (three times), inflammatory disorders of intestine (five

times), intestinal adhesions (two times), ovarian cysts (six times: one time with mesenteric lymphadenitis, one time ruptured), tubo-ovarian abscess (one time), tubal necrosis (one time), adnexitis with mesenteric lymphadenitis (one time), and acute cholecystitis (one time). These diagnoses might have been missed during conventional open appendectomy and were, if necessary, treated during laparoscopy.

Conclusions Laparoscopic appendectomy should be recommended as standard procedure for acute appendicitis.

Keywords Laparoscopic appendectomy · Acute suspected appendicitis · Laparoscopic findings · Cost-effectiveness

L. I. Partecke · A. Karrasch · J. Tepel
Department of Surgery, St. Adolf-Stift Hospital,
Reinbek, Germany

L. I. Partecke · W. von Bernstorff · K. Cziupka · A. Glitsch ·
A. Stier · C. D. Heidecke
Department of General, Visceral, Thoracic and Vascular Surgery,
University Hospital Greifswald,
Ernst-Moritz-Arndt-University,
Greifswald, Germany

J. Tepel
Department of General, Visceral and Thoracic Surgery,
Klinikum Osnabrück,
Osnabrueck, Germany

L. I. Partecke (✉)
Department of General, Visceral, Thoracic and Vascular Surgery,
Universitätsklinikum Greifswald,
Ernst-Moritz-Arndt-University Greifswald,
Friedrich-Loeffler-Str. 23b,
17489 Greifswald, Germany
e-mail: Partecke@uni-greifswald.de

Introduction

Acute appendicitis is the most common cause of acute abdominal pain in the western hemisphere. The incidence approximates 100/100,000 people per year. With a general life time risk of 7–8%, the appendectomy accounts for one of the most common operations in general surgery [1]. Laparoscopic appendectomy was first published 1983 by Semm [2]. Thereafter, several studies have shown the safety of this procedure [3, 4]. However, laparoscopic appendectomy has not (yet) evolved as the gold standard for the treatment of acute appendicitis. In many surgical centres, open appendectomy remains to be the standard surgical practice for acute appendicitis. In fact, only 54% of all appendectomies carried out in Germany in 2006 were performed using a laparoscopic approach [5]. Furthermore, a nationwide survey of appendectomies in England between 1996 and 2006 revealed that the laparoscopic technique was employed in only 6.3% [6].

The conventional open operation usually follows a standardised procedure. In contrast, many different techniques have been used for laparoscopic appendectomies. Namely, the positioning of trocars and the closure of the base of the appendix vary greatly, thus demonstrating that no single technique has so far shown superiority. Since 1990, the advantages and disadvantages of laparoscopic appendectomy have been analysed in more than 40 studies [7, 8]. Some studies could show an advantage for the laparoscopic technique resulting in fewer wound infections, less pain following surgery, better cosmetic results, decreased hospitalisation, and earlier start of work. However, many studies have also demonstrated an increased time of surgery, increased risk for intra-abdominal abscesses and significantly higher costs for surgery when compared to conventional surgery [9–14]. An evidence-based advantage for the laparoscopic procedure has been shown only for young fertile females and for obese patients [15]. Also, it has been recommended for men with atypical pain of uncertain diagnosis [16]. These discrepancies led to the initiation of this prospective trial. Our purpose was to find out whether the laparoscopic approach could be adopted as the standard procedure for appendectomy when acute appendicitis was clinically suspected. Also, a major point of interest was the prevalence of diagnoses other than appendicitis, which could be diagnosed, and if necessary, be treated during laparoscopy. Further parameters of interest were the cost-effectiveness of the laparoscopic procedure using a monofilament polydioxanone (PDS)-loop as a nonstapler technique, the morbidity of patients following laparoscopic appendectomy, and the total time of surgery of the laparoscopic approach, all compared to open appendectomy.

Patients and methods

We prospectively evaluated 400 patients for a period of 14 consecutive months who presented with acute onset of right lower quadrant pain at the Department of Surgery, St. Adolf-Stift Hospital, Reinbek, Germany. Prior to commencing the study, it had been approved by the hospital institutional review board. Eventually, 165 patients (62 males, 103 females; mean age 29.2 years, age range 6–87 years) were operated on for clinically and/or ultrasonographically suspected acute appendicitis. All other patients had been admitted to the hospital for observation and improved over time without requiring surgery. All 17 children (seven boys and ten girls, mean age 9.5 years, age range 6–12 years) below the age of 13 years were primarily operated on performing open appendectomy. This control group (open appendectomy group) was not included in this study and was not matched in any variables with the study group. It

was only used for comparison purposes. The remaining 148 patients were 55 males and 93 females (mean age 31.4 years, age range 13–87 years) and formed the basis of this study.

The following parameters were documented for later evaluation: patients' age and sex, their clinical history and examination including rectal and axillary temperature, investigations including white cell count, C-reactive protein, and abdominal ultrasound.

If acute appendicitis was suspected, the decision for surgery was always made by a board-certified surgeon. The surgical procedure followed a standardised protocol: Before starting anaesthesia, patients received a single dose of antibiotics consisting of cefuroxim (1.5 g i.v.) and metronidazole (500 mg i.v.). After skin disinfection and the placement of sterile drapes, the skin was incised just along the inferior umbilical edge. A reusable safety cannula (Verres cannula) was placed into the abdomen using the usual safety tests. Then, the abdominal cavity was inflated with carbon dioxide. A reusable 12-mm trocar for the camera was placed through the infraumbilical incision. After thoroughly checking the abdominal cavity for pathologic findings other than appendicitis including adhesions and bleeding, a 10-mm trocar was positioned within the right lower quadrant. A 5-mm trocar was placed within the left lower quadrant. After positioning the patient in a Trendelenburg right up left low position, the appendix was identified. The mesoappendix was dissected starting at the base of the appendix by tunnelling the mesoappendix right at the edge of the appendix. The mesoappendix was divided using a bipolar electric cauter including safely cauterising the appendicular artery. Following complete dissection the proximal base of the appendix was ligated using a PDS-loop (Roeder PDS loop, Ethicon, Norderstedt, Germany). The distal base was ligated using the remaining part of the PDS-loop. Between both ligatures, the appendix was cut. If possible, the appendix was then born via the 12-mm trocars. In cases of late-stage appendicitis, including gangrenous and perforated appendicitis, the appendix was removed with a specimen bag, usually via the infraumbilical access using a dilator. Depending on the stage of appendicitis, the abdominal cavity was lavaged, and in late-stage appendicitis, this was followed by the placement of a small capillary drain via the left lower quadrant trocar. In cases of frank gangrenous or perforated appendicitis or after abscess formation, a drain was always used. In these cases, double antibiotics were continued for 3 days following surgery (cefuroxim 3×1.5 g/day, metronidazole 2×500 mg/day).

If the inflammation of the appendix was approaching the base of the appendix and a placement of the loop would have been too risky, an endoscopic stapler for the transection of the appendix was used. In cases of inflammatory caecal involvement, the procedure was converted to open surgery.

All relevant patient data were documented in a database including complications during hospitalisation as well as histology reports including final diagnoses. Furthermore, all additional and/or unexpected findings during laparoscopy were documented and analysed as a separate study parameter.

A cost analysis was done after collecting prices of all relevant materials, including sutures, specimen bags, drains, etc., that were used during surgery for laparoscopic and for open appendectomy.

Statistical analyses were performed using GraphPad InStat version 3.06 (GraphPad Software Inc., San Diego, California USA). The unpaired Mann–Whitney test was used to compare means.

Results

In this study, 148 patients with suspected acute appendicitis primarily underwent laparoscopy. Laparoscopy proved to be safe and efficient to treat acute appendicitis. Even young surgeons in training could safely perform the operation with no increase of the rate of complications during surgery.

Mean time of laparoscopic appendectomies was 47 min with a range of 15–97 min. In cases of perforated appendicitis, the mean time of laparoscopy was 67 min ranging from 51 to 97 min whereas simple laparoscopic appendectomies could be performed significantly faster within a mean time of 42 min ($p < 0.05$; range 15–63 min). Procedures that were started laparoscopically but had to be converted to an open approach had a mean time of surgery of 75 min with a range of 47–103 min. This was significantly longer than simple ($p < 0.001$) or perforated appendectomies ($p < 0.05$).

Further subgroup analyses revealed that 69.8% of all laparoscopic appendectomies were performed within 60 min and 46.9% of laparoscopic appendectomies of uncomplicated appendicitis could be finished within 45 min (Table 1).

Children below the age of 13 years (17 patients in this study) were always treated by open appendectomy. All 17 children had nonperforated appendicitis. Although this is not a randomised study and despite the fact that surgery in children is usually easier and faster than in adults, partly due to less body fat and easier identification of anatomical structures, we have compared mean times of surgical procedures of nonperforated appendicitis between laparoscopic (42 mins) and open appendectomies (38 min). However, comparing the limited available data, we could not find a significant difference between the laparoscopic and the open approach ($p = 0.28$).

In all seven of 148 patients in which laparoscopic appendectomy had to be converted to open surgery (4.7%), the

Table 1 Duration of surgical procedures

Laparoscopic appendectomies ($n=141$)	
Mean time of surgery: 47 min	
Nonperforated appendicitis ($n=126$)	
Mean time of surgery: 42 min	
15–30 min	13.5% (17)
31–45 min	46.9% (59)
46–60 min	19.8% (25)
>60 min	19.8% (25)
Perforated appendicitis ($n=15$)	
Mean time of surgery: 67 min	
46–60 min	13.3% (2)
>60 min	86.7% (13)
Laparoscopically started then converted open appendectomies ($n=7$)	
Mean time of surgery: 75 min (range 47–103 min)	
46–60 min	14.3% (1)
>60 min	85.7% (6)
Primary open appendectomies ($n=17$)	
Only children 6–12 years, all nonperforated	
Mean time of surgery: 38 min	
15–30 min	23.5% (4)
31–45 min	58.8% (10)
46–60 min	11.8% (2)
>60 min	5.9% (1)

reason for conversion was an inflammatory involvement of the base of the appendix including the distal parts of the caecum. In all patients with perforated appendicitis (15/148; 10.1%), surgery could be completed laparoscopically. In 12 of these patients, the appendix was located in a retrocaecal position and in three of these patients in a left pelvic position. The mean time of surgery of these patients was 67 min ranging from 51 to 97 min.

The total rate of complications was 13% with no complications during primary surgery (e.g. bleeding, trocar injury) and no wound infections following surgery. Also, after discharging the patients, none of them presented with further complications, and neither of them required rehospitalisation.

Complications comprised of surgery-related and surgery-unrelated complications. The rate of surgery-unrelated complications was 3.2% including two patients (1.2%) with pneumonia and three patients (2.0%) with urinary tract infections. Both types of infection could successfully be treated by antibiotics.

The rate of surgery-related complications was 9.8% including one haematoma of a trocar canal, two cases of an early ileus, and three cases of an inflammatory pseudotumour of the bowel, all of which could be treated without surgery. Seven patients developed intra-abdominal abscesses (4.7%). Five of these patients could be treated by placement of an ultrasound-guided flush drain into the

abscess and an additional double antibiotic regimen (as above). One patient required a secondary laparoscopy for draining the abscess, and one patient required a laparotomy and an open drainage of the abscess. Both patients also received additional double antibiotic therapy (as above). No patient following perforated appendicitis developed an intra-abdominal abscess. Interestingly, we have not seen any abdominal wound infections in our study patients so far. Using the monofilament PDS-loop as a nonstapler technique for ligation of the appendiceal stump we have not seen any stump leaks either.

Twenty-one patients (14.2%) primarily operated on for suspected acute appendicitis had unexpected findings during laparoscopy. Those findings which required surgical treatment could be accomplished during laparoscopy. These patients were nine males and 12 females with a mean age of 38.6 years and an age range of 14–81 years. All 21 patients had had an abdominal ultrasound before surgery, and all females had presented to a gynaecologist for a gynaecological status before surgery.

Following unexpected findings were seen during laparoscopy (Table 2):

Three patients had inflamed epiploic appendices which were resected. One patient had a local inflammation of the ileum resolving after double antibiotic treatment (as above). Four patients had an inflammatory disorder of the large

bowel: two patients had a local colitis, one patient of the caecum, and the other one of the ascending colon. One patient had diverticulitis of the ascending colon, and one patient had diverticular disease with acute diverticulitis of the sigmoid colon. In all four patients, complaints were resolved following double antibiotic treatment as above. In neither of the latter five patients, a chronic inflammatory bowel disorder like Crohn' disease or ulcerative colitis could be diagnosed following later investigations including colonoscopy. Two patients had intestinal adhesions which were dissected. Five patients had right ovarian cysts, one of these with accompanying mesenteric lymphadenitis, and one had a ruptured cyst. The cysts were treated by laparoscopic fenestration. One patient had a tubo-ovarian abscess; the abscess was drained, and the right tube and ovary had to be removed. One patient had a haemorrhagic necrosis of the right tube requiring resection of the tube. One patient had an adnexitis with accompanying mesenteric lymphadenitis which was treated by antibiotics. In all cases of gynaecological disorders, a gynaecologist was consulted during surgery. One patient suffered from acute cholecystitis and could be treated by laparoscopic cholecystectomy. In 24 cases, a histologically uninflamed appendix was removed (16.2%). Eight of these patients (5.4%) were suffering from neuroimmune appendicitis. Therefore, in this series, the rate of false negative appendectomies was 10.8%.

Table 2 Unexpected findings and diagnoses during surgery and findings on ultrasound before surgery

	Diagnosis	Sex	Age	Findings on ultrasound
1	Inflamed epiploic appendices	♂	74 years	Pathological caecum/coecal process
2	Inflamed epiploic appendices	♂	27 years	No specific findings
3	Inflamed epiploic appendices	♂	76 years	Target phenomenon/appendicitis
4	Local inflammation of small intestine	♂	32 years	Free intra-abdominal fluid
5	Colitis of caecum	♂	29 years	Free intra-abdominal fluid/appendicitis
6	Haemorrhagic necrosis of the omentum	♂	58 years	Appendicitis
7	Diverticulitis of sigmoid colon	♂	59 years	Appendicitis/coprolith
8	Diverticulitis of ascendine colon	♂	38 years	Appendicitis, free intra-abdominal fluid
9	Ileus due to adhaesions	♂	33 years	Motility disorder of small intestine in right lower quadrant
10	Cyst of right ovary	♀	40 years	Free intra-abdominal fluid
11	Serous cyst of right ovary	♀	23 years	No specific findings
12	Cyst of right ovary	♀	28 years	No specific findings
13	Right ovarian cyst, mesenteric lymphadenitis	♀	39 years	Appendicitis
14	Hydrosalpinx	♀	17 years	No specific findings
15	Ruptured cyst of right ovary	♀	18 years	Free intra-abdominal fluid
16	Abscess of right tube and ovary	♀	25 years	No specific findings
17	Haemorrhagic necrosis of the right tube	♀	40 years	No specific findings
18	Adnexitis, mesenteric lymphadenitis	♀	14 years	Free intra-abdominal fluid
19	Local colitis of ascending colon	♀	28 years	Free intra-abdominal fluid
20	Empyema of gallbladder	♀	81 years	No specific findings
21	Adhaesions	♀	43 years	Free intra-abdominal fluid

Table 3 Costs of open and laparoscopic appendectomies

Open appendectomy
Sutures: €31.13 (ligation of appendiceal stump, purse string suture, peritoneum, fascia, subcutaneous tissue, skin)
Laparoscopic appendectomy
PDS-loop: €19.00
Sutures: fascia and skin: €6.60
Stapler + magazine: €356.43
Specimen bag: €75.00
Optional: Hem-o-Lok MLX polymeric Clips
1 box including 14 units: €279.17 (1 unit serves 1 operation)
1 unit containing 6 clips: €19.94 (1 unit serves 1 operation)

The costs of materials for open and laparoscopic appendectomy are summarised in Table 3. Total costs for open appendectomy were €31.13, and total costs for simple laparoscopic appendectomy were €25.60. For laparoscopic appendectomy, this was increased per case by €75.00 if a specimen bag had to be used and by €356.43 if a stapler was necessary for transecting the appendix. A specimen bag was necessary in 46/148 cases, and a stapler had to be used in 11/148 (7.4%) operations. This increased the mean costs of the laparoscopic approach per operation in this cohort by €23.31 (46 bags/148)+€26.67 (11 staplers/148). The costs for, e.g. dressings, gloves, lavage fluid, if necessary, were not taken into consideration since those would have been used in both approaches.

In seven patients, laparoscopy had to be converted to an open approach due to inflammatory involvement of the base of the appendix and parts of the caecum. In these patients, even a stapler transection of the appendix was not possible. The costs for laparoscopy including only sutures were €6.60, and the costs for the open approach were €31.13. Costs for the additional use of instruments for open surgery are difficult to calculate and were not included.

Discussion

In the present study, we could show that laparoscopic appendectomy is safe. It has evolved as the standard procedure at the Department of Surgery at St. Adolf-Stift Hospital, Reinbek, Germany. Meanwhile, it is also the treatment of choice at the Department of General, Visceral, Thoracic, and Vascular Surgery of the Universitätsklinikum Greifswald, Ernst-Moritz-Arndt-University, Greifswald and at the Department of General, Visceral and Thoracic Surgery, Klinikum Osnabrück, Germany. Laparoscopic appendectomy can be carried out even by young surgeons in training. As the mean time of laparoscopic appendecto-

mies was 47 min ranging from 15 to 97 min, we could show that laparoscopic appendectomy could be performed within an acceptable time frame, even as a training procedure. When comparing laparoscopic appendectomies with open appendectomies using our own limited and nonrandomized data, we could not show any significant differences between both approaches. Although earlier studies have suggested a slight advantage of open surgery over laparoscopy considering time of surgery [7, 8, 11, 12], other and more recent studies have shown no such advantage [15] or even longer times of surgery for the open approach [17]. Further advantages of the laparoscopic approach include fewer wound infections, less pain following surgery, better cosmetic results, decreased hospitalisation, and earlier start to work [7, 8, 11, 12]. In fact, in this study, we have not seen any wound infections. Also, the rate of intra-abdominal abscess formation of 4.7% (7/148 patients) was acceptable compared to data of the literature showing 3.1–5.3% of intra-abdominal abscesses following laparoscopic appendectomies and 0–3.0% of intra-abdominal abscesses following open appendectomies. Fortunately, most abscesses (i.e. five patients) could be treated by the placement of ultrasound-guided drains, and only two patients required surgery. Other series have shown similar approaches and results [12, 14, 17].

More importantly, in cases of suspected acute appendicitis, the laparoscopic approach offers an additional diagnostic tool at the time of surgery. Unsuspected findings during laparoscopy have also been published by Barrat et al. [18] who described 46 of a total of 306 patients (i.e. 15.0%) suffering from disorders other than appendicitis. In ten patients, no pathologies were found. Barrat et al. also concluded that some diagnoses might have been overlooked with a classical McBurney incision. In another study, van den Broek et al. [19] investigated the use of diagnostic laparoscopies in patients with suspected appendicitis and obtained diagnoses other than acute appendicitis in 14.3% of 377 patients with suspected appendicitis, most of them (72%) gynaecologic in nature but also including adhesions, mesenteric lymphadenitis, and diverticulitis.

Even ultrasound, the diagnostic tool with the highest specificity, positive predictive value, and highest accuracy to correctly diagnose acute appendicitis [20] fails in some cases. It is important to mention that six of the aforementioned nine patients had findings on ultrasound resembling acute appendicitis. The diagnoses of these nine patients, in particular epiploic appendicitis and partial haemorrhagic necrosis of the greater omentum, would have probably been missed during open surgery.

At the same time, eight of 12 females, who all did not have acute appendicitis, eventually proved to suffer from gynaecological disorders, although they had been consulted by gynaecologists preoperatively. In these patients, ultra-

sound did not reveal any specific findings apart from free intra-abdominal fluid in five patients. At the time of surgery, their unexpected findings might also have been overlooked if open surgery had been performed. As has already been published, an important factor for a correct diagnosis of acute appendicitis is the experienced surgeon [20]. This should always be completed by imaging modalities. This will reduce the number of negative appendectomies yet assure low perforation and mortality rates [21]. However, this has been controversially discussed. Some authors have favoured computed tomography (CT) imaging in all cases of adult patients with suspected acute appendicitis [22]. Others have shown that CT and graded compression sonography have a similar accuracy for the diagnosis of acute appendicitis [23]. In atypical cases and patients with a large body habitus, computed tomography displays some advantages, however, at the expense of significant radiation exposure, increased costs, and possible complications from contrast media [24]. Finally, it should be born in mind that a certain percentage of patients suffers from neuroimmune appendicitis and may be referred to hospitals several times with clinical signs of appendicitis yet uninfamed appendices [25]. In these patients, imaging studies will always be negative, yet the possible endless course of suffering will only end after appendectomy. Therefore, not a single imaging study but the combination of history taking, physical examination, laboratory tests, and imaging studies should guide the surgeon in his (or her) decision. If surgery is warranted, laparoscopy should be the treatment of choice. In fact, in open surgery, surgical treatment of findings other than appendicitis usually require larger or different surgical accesses resulting in more severe surgical trauma including a possible increase in postsurgical complications. Indeed, we have seen a case of acute late-stage gangrenous appendicitis of a young female who had a ruptured ovarian cyst and ectopic tubal pregnancy at the same time. Since she had late-stage appendicitis, the other findings would have very likely been overlooked (unpublished data). Furthermore, Larsson et al. [26] and Barras et al. [18] presented data stating that some of their unexpected findings also very likely would have been overlooked if open appendectomy had been performed.

In cases of suspected appendicitis, the laparoscopic approach is of significant diagnostic value. First, it can con-

firm the initial diagnosis if appendicitis is present. Second, laparoscopy offers an additional diagnostic tool to diagnose additional or other pathologic findings. Third, laparoscopy offers further therapeutic options to treat additional or other pathologic findings and/or diseases at the time of laparoscopy. And last, laparoscopy can aid in the process of planning future medical or surgical treatment modalities, if immediate treatment of pathologic findings is not the primary goal.

In our study, we could show that the closure of the base of the appendix was safely done using only one PDS-loop. The safety of using only one loop has been shown by Beldi et al. [27]. They confirmed that an inversion of the stump of the appendix base was not necessary if the base was not inflamed. In cases of an inflamed base of the appendix, we advocate the use of an endostapler. In this study, it was only necessary in 7.4% of all cases (11/148) and did increase the total costs per case by only €26.67 in laparoscopic appendectomy. These results are in contrast to a meta-analysis by Kazemier et al. [28] who compared the use of endoscopic staplers and loop ligatures. Kazemier et al. conclude that the routine use of staplers appears to be preferable to loop ligatures, but increases the cost per patient ratio at the same time. However, Arcovedo et al. [29] confirmed our results demonstrating in their study that the use of a simple cost-effective sliding knot is as safe as the stapler for the closure of the appendiceal stump. More recently, at the Department of General, Visceral, Thoracic and Vascular Surgery of the Universitätsklinikum Greifswald, Ernst-Moritz-Arndt-University, we have changed this approach by replacing the PDS-loop by simple nonabsorbable clips (Hem-o-lock MLX polymeric Clips, Weck Closure Systems, NC, USA) as has been suggested by Hanssen et al. [30]. This approach simplifies the procedure and resembles the clipping of the cystic duct performed for cholecystectomies. Thereby, the time and effort for laparoscopic appendectomies can be further reduced with an increase of the degree of standardisation at the same time. The costs for the clips, listed in Table 3, are almost the same as for the PDS-loop leaving the surgeon three additional clips. The safety of the clips has been shown to be similar to the use of staplers [30].

Regarding the costs of laparoscopic and open appendectomy, the reusable trocars should be available in most

Table 4 Comparisons of the costs of surgery for open and laparoscopic appendectomies

Open appendectomy	Laparoscopic appendectomy	Cost difference
Standard open appendectomy €31.13	Standard laparoscopic approach €25.60	€-5.53
	Laparoscopic approach with specimen bag €100.60	€+69.47
	Laparoscopic approach with stapler €382.03	€+350.90
	Laparoscopic approach with stapler and specimen bag €457.03	€+425.90

surgical clinics also performing laparoscopic surgery such as laparoscopic cholecystectomies, hernia repairs, or funduplications. In cases of simple appendicitis, the costs did not differ significantly. In cases in which specimen bags or staplers had to be used or if laparoscopy had to be converted to an open approach, the costs per case increased significantly (Table 4). Taken into consideration all factors of this study, the additional costs per case of laparoscopic appendectomy were increased by €49.98. However, laparoscopy offers an additional diagnostic and therapeutic tool. This fact, fewer wound infections, less pain following surgery, better cosmetic results, decreased hospitalisation, and the significantly earlier return to work compensate largely for the above-mentioned moderate increase in costs.

Conclusions

The above-presented data suggest that laparoscopic appendectomy using a monofilament PDS-loop (or clips) for ligating the appendical stump offers a safe and cost-effective approach in acute appendicitis. It could be carried out in advanced stages of appendicitis within an acceptable time frame even by young surgeons in training. Furthermore, the laparoscopic approach was of significant additional diagnostic value enabling the surgeon to see and treat additional and/or other pathologic findings which might have been missed using an open approach. These advantages have already been described for young female patients. In this prospective study, we could show that the same was true for male patients. Therefore, we believe that laparoscopic appendectomy should be recommended as the standard procedure for all patients with suspected appendicitis.

References

- Hardin DM Jr (1999) Acute appendicitis: review and update. *Am Fam Physician* 60:2027–2034
- Semm K (1983) Endoscopic appendectomy. *Endoscopy* 15:59–64
- Hansen JB, Smithers BM, Schache D, Wall DR, Miller BJ, Menzies BL (1996) Laparoscopic versus open appendectomy: prospective randomized trial. *World J Surg* 20:17–20 Discussion 21
- Reiertsen O, Trondsen E, Bakka A, Andersen OK, Larsen S, Rosseland AR (1994) Prospective nonrandomized study of conventional versus laparoscopic appendectomy. *World J Surg* 18:411–415 discussion 415–416
- Reissfelder C, Mc Cafferty B, von Frankenberg M (2009) Open appendectomy. When do we still need it? *Chirurg* 80:602–607
- Faiz O, Clark J, Brown T, Bottle A, Antoniou A, Farrands P, Darzi A, Aylin P (2008) Traditional and laparoscopic appendectomy in adults: outcomes in English NHS hospitals between 1996 and 2006. *Ann Surg* 248:800–806
- Golub R, Siddiqui F, Pohl D (1998) Laparoscopic versus open appendectomy: a metaanalysis. *J Am Coll Surg* 186:545–553
- Sauerland S, Lefering R, Holthausen U, Neugebauer EA (1998) Laparoscopic vs conventional appendectomy—a meta-analysis of randomised controlled trials. *Langenbecks Arch Surg* 383:289–295
- Towfigh S, Chen F, Mason R, Katkhouda N, Chan L, Berne T (2006) Laparoscopic appendectomy significantly reduces length of stay for perforated appendicitis. *Surg Endosc* 20:495–499
- Yagmurlu A, Vernon A, Barnhart DC, Georgeson KE, Harmon CM (2006) Laparoscopic appendectomy for perforated appendicitis: a comparison with open appendectomy. *Surg Endosc* 20:1051–1054
- Pedersen AG, Petersen OB, Wara P, Ronning H, Qvist N, Laurberg S (2001) Randomized clinical trial of laparoscopic versus open appendectomy. *Br J Surg* 88:200–205
- Milewicz M, Michalik M, Ciesielski M (2003) A prospective, randomized, unicenter study comparing laparoscopic and open treatments of acute appendicitis. *Surg Endosc* 17:1023–1028
- Ignacio RC, Burke R, Spencer D, Bissell C, Dorsainvil C, Lucha PA (2004) Laparoscopic versus open appendectomy: what is the real difference? Results of a prospective randomized double-blinded trial. *Surg Endosc* 18:334–337
- Katkhouda N, Mason RJ, Towfigh S, Gevorgyan A, Essani R (2005) Laparoscopic versus open appendectomy: a prospective randomized double-blind study. *Ann Surg* 242:439–448 discussion 448–450
- Sauerland S, Lefering R, Neugebauer EA (2004) Laparoscopic versus open surgery for suspected appendicitis. *Cochrane Database Syst Rev* CD001546
- Mutter D, Vix M, Bui A, Evrard S, Tasseti V, Breton JF, Marescaux J (1996) Laparoscopy not recommended for routine appendectomy in men: results of a prospective randomized study. *Surgery* 120:71–74
- Kehagias I, Karamanakis SN, Panagiotopoulos S, Panagopoulos K, Kalfarentzos F (2008) Laparoscopic versus open appendectomy: which way to go? *World J Gastroenterol* 14:4909–4914
- Barrat C, Champault G, Catheline JM, Rizk N, Zioli M, Guettier C (1998) Does laparoscopy reduce the incidence of useless appendectomies? *Ann Chir* 52:965–969
- van den Broek WT, Bijnen AB, van Eerten PV, de Ruyter P, Gouma DJ (2000) Selective use of diagnostic laparoscopy in patients with suspected appendicitis. *Surg Endosc* 14:938–941
- Tepel J, Sommerfeld A, Klomp HJ, Kapischke M, Eggert A, Kremer B (2004) Prospective evaluation of diagnostic modalities in suspected acute appendicitis. *Langenbecks Arch Surg* 389:219–224
- Lee SL, Ho HS (2003) Ultrasonography and computed tomography in suspected acute appendicitis. *Semin Ultrasound CT MR* 24:69–73
- Blebea JS, Meilstrup JW, Wise SW (2003) Appendiceal imaging: which test is best? *Semin Ultrasound CT MR* 24:91–95
- Poortman P, Lohle PN, Schoemaker CM, Oostvogel HJ, Teepen HJ, Zwinderman KA, Hamming JF (2003) Comparison of CT and sonography in the diagnosis of acute appendicitis: a blinded prospective study. *AJR Am J Roentgenol* 181:1355–1359
- Old JL, Dusing RW, Yap W, Dirks J (2005) Imaging for suspected appendicitis. *Am Fam Physician* 71:71–78
- Di Sebastiano P, Fink T, di Mola FF, Weihe E, Innocenti P, Friess H, Buchler MW (1999) Neuroimmune appendicitis. *Lancet* 354:461–466
- Larsson PG, Henriksson G, Olsson M, Boris J, Stroberg P, Tronstad SE, Skullman S (2001) Laparoscopy reduces unnecessary appendectomies and improves diagnosis in fertile women. A randomized study. *Surg Endosc* 15:200–202

27. Beldi G, Muggli K, Helbling C, Schlumpf R (2004) Laparoscopic appendectomy using endoloops: a prospective, randomized clinical trial. *Surg Endosc* 18:749–750
28. Kazemier G, Hof KH, Saad S, Bonjer HJ, Sauerland S (2006) Securing the appendiceal stump in laparoscopic appendectomy: evidence for routine stapling? *Surg Endosc* 20:1473–1476
29. Arcovedo R, Barrera H, Reyes HS (2007) Securing the appendiceal stump with the Gea extracorporeal sliding knot during laparoscopic appendectomy is safe and economical. *Surg Endosc* 21:1764–1767
30. Hanssen A, Plotnikov S, Dubois R (2007) Laparoscopic appendectomy using a polymeric clip to close the appendicular stump. *Jsls* 11:59–62