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ORIGINAL ARTICLE

Laparoscopic appendectomy as a teaching procedure: experiences with 1197 patients in a community hospital

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Abstract
Purpose Since laparoscopic procedures have become more common, resident surgeons have to learn complex laparoscopic skills at an early stage of their career. The aim of this study was to compare the short-term clinical outcome parameters of laparoscopic appendectomy (LA) performed by resident surgeons (RS) or attending surgeons (AS).
Methods A total of 1197 LA and 57 open appendectomies were performed in a Swiss community hospital between 1999 and 2009. RS performed 684 operations. Parameters including the duration of the operation and hospital stay, intraoperative complications, surgical reinterventions, and a 30-day morbidity and mortality were observed.
Results The mean age of the patients was 35.6 ± 18.17 years. The duration of the operation was longer (61.34 ± 25.73 min [RS] vs. 53.65 ± 29.89 [AS] min; $p = 0.0001$), but the hospital stay was shorter, in patients treated by RS (3.92 ± 2.61 days [RS] vs. 4.87 ± 3.23 [AS] days; $p = 0.0001$). The rate of intraoperative complications was not significantly different between the two groups (1.02 % [RS] vs. 0.8 % [AS]; $p = 0.6$). The need for surgical reintervention (0.6 % [RS] vs. 2.5 % [AS]; $p = 0.005$) and the 30-day morbidity were higher in patients treated by AS (3.7 % [AS] vs. 1.8 % [RS]; $p = 0.04$). There was no postoperative mortality.
Conclusions Under appropriate supervision, surgical residents are able to perform LA with results comparable to those of experienced surgeons.

Keywords Laparoscopic appendectomy · Teaching operation · Morbidity · Outcomes

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Introduction

During the last few years, minimally invasive procedures have replaced several open procedures [1]. The reasons for this development are that these procedures result in less postoperative pain [2], faster recovery [3], and a shorter hospital stay [4] which led to an increased public demand.

Compared to open procedures, laparoscopic surgery is technically more demanding and requires good visual perception when looking at a monitor while working in the abdominal cavity. Except by verbal communication, an experienced assistant cannot help an inexperienced surgeon with the movements in the surgical field [5] which makes it difficult to teach complex surgical procedures without harming patients.

Open appendectomy (OA) was traditionally seen as a training procedure for young surgeons [6]. The trend toward laparoscopic procedures led to a shift from the previous technical easy open procedures to technically advanced laparoscopic operations that were usually performed by experienced surgeons [7]. Therefore, young surgeons now have to learn laparoscopic interventions at an early stage of their surgical training [1]. Therefore, laparoscopic appendectomy might serve as an introductory procedure for more complex surgeries, as, e.g., colorectal interventions [8].

Because of increasing public demand for high quality and cost effectiveness [9], modern teaching hospitals have

to both serve the public demand and simultaneously guarantee the surgical education of young surgeons [10]. Previous studies showed that laparoscopic operations performed by resident surgeons (RS) were associated with higher costs [11, 12] but without higher morbidity [11]. Therefore, a structured education with an appropriate instruction provided by an attending surgeon (AS) to avoid complications during the learning curve [13] might help to overcome the controversies associated with inexperienced surgeons performing complex procedures on actual patients.

For this study we chose LA as a frequently performed laparoscopic procedure which could be easily learned by RS at the beginning of their surgical training. A prospectively led clinical database was retrospectively analyzed. The intraoperative and postoperative short-term outcomes of LA were compared between RS and AS.

Methods

Clinical setting

Between 1 January 1999 and 31 December 2009, 1254 appendectomies were performed to treat appendicitis in a Swiss community hospital with 300 beds in an urban environment of about 1.5 million inhabitants. A total of 1197 (95.5 %) of these procedures were laparoscopic procedures. Laparoscopic appendectomy was the treatment of choice. During the last few years of the observation period, open procedures were performed only in children, and none were performed in adult patients. Strictly defined surgical residents who had at least 2 years of surgical training performed the LA. All operations performed by residents were performed under the guidance of fully trained board certified attending surgeons.

Surgical technique

LA was performed using a standard technique. After the creation of a pneumoperitoneum with a pressure of 15 mmHg using a verres needle, a total of three ports were inserted. First, a general exploration of the abdominal cavity was performed to rule out other pathological findings. After identification of the cecum and appendix, the appendix was mobilized to the base, divided between loop ligatures or using an endo-stapler, and finally removed using a laparoscopic bag. At the end of the operation, the abdominal cavity was irrigated with warm saline solution. In cases with a perforated appendicitis and severe peritonitis, a silicon drain was placed. The fascial defects were closed with absorbable sutures, and the skin with non-absorbable sutures.

In the case of an OA a muscle splitting incision in the right lower quadrant was performed first. The appendix was divided, and the stump was closed using an absorbable suture. After irrigation of the abdominal cavity, the fascial defect was closed with an absorbable suture, and the skin with a non-absorbable suture.

Data collection

This retrospective analysis was based on a prospectively led clinical database of the AQC (Swiss quality working group, [14]). The AQC was founded in 1995 as a voluntary quality working group of Swiss surgical departments. The obtained data were entered into a centralized database (Qualicare, Qualidoc, Liebefeld-Bern, Switzerland) and analyzed by each surgical department.

All data in this study were obtained and analyzed in strict adherence to the ethical guidelines for human research of the Swiss Academy of Medical Sciences (Schweizerische Akademie der Medizinischen Wissenschaften; http://www.samw.ch/docs/Richtlinien/d_Forschungsunters.pdf.) and according to the University of Zürich Institutional Review Board guidelines.

Clinical outcome parameters

The baseline demographic data were recorded including the patient gender, age and American Society of Anaesthesiologists (ASA) score, body mass index (BMI) and whether the patient had complicated appendicitis with peritonitis or perforation of the appendix. Furthermore, the surgical expertise (RS vs. AS), intraoperative complications (lesions of the intestine or colon, bleeding), duration of operation, length of hospital stay, surgical reintervention, the 30-day morbidity (surgical site infection, incisional hernia, ileus, pleural effusion, arrhythmia, stroke, allergic reaction) and in-hospital mortality were analyzed.

Statistical analysis

The data are presented as the means and standard deviation. The descriptive and univariate group-wise statistical analyses were performed using the SigmaStat 3.11.0 software program (Systat Software, Richmond, CA, USA) with $p < 0.05$ defined as statistically significant.

Results

Study collective

During the 11-year study period, 1254 appendectomies were performed, of which 1197 were LAs (95.5 %; male

Table 1 Patient background

	Treated by RS	Treated by AS	*p*
Number of patients	684 (57 %)	513 (43 %)	0.02
Males	380 (55 %)	236 (46 %)	0.001
Mean age (years)	31.69 ± 16.5	40.91 ± 19.01	0.0001
ASA score			
I	485 (70.9 %)	312 (60.8 %)	0.003
II	180 (26.3 %)	172 (33.5 %)	0.007
III	19 (2.8 %)	29 (5.7 %)	0.001
BMI			
<25	427 (62.5 %)	281 (55%)	0.008
25–29.99	207 (30 %)	156 (30 %)	0.9
30–34.99	40 (6 %)	62 (12 %)	0.0002
>35	10 (1.5 %)	14 (3 %)	0.1
Complicated appendicitis	42 (6 %)	72 (14 %)	0.0001

RS resident surgeon, *AS* attending surgeon, *ASA* American Society of Anaesthesiologists, *BMI* body mass index in kg/m^2

$n = 616$, 51.5 %). A total of 33 % of the OA were performed in patients younger than ten. The majority of patients with LA were treated by RS ($n = 684$, 57 %). The mean age of the patients was 31.69 ± 16.5 years in those treated by RS and 40.91 ± 19.01 years in those treated by AS ($p = 0.0001$, Table 1). All operations were performed as emergency procedures. Patients with low ASA scores (I–II) were treated significantly more often by RS, whereas patients with an ASA score III underwent surgery by an AS significantly more often. There was a significant preponderance of patients with a lower BMI in the resident group compared to patients in the attending group. The patients treated by AS had significantly higher rates of complicated appendicitis than patients treated by RS (Table 1).

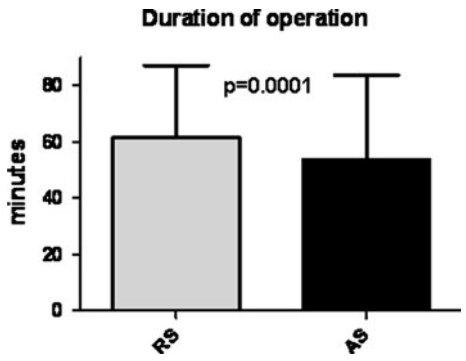

Fig. 1 The duration of the operation (in min) for laparoscopic appendectomies performed by resident surgeons (RS) versus attending surgeons (AS)

Intraoperative course

The mean duration of the operation was longer for the LA performed by RS compared to AS (61.34 ± 25.73 min [RS] vs. 53.65 ± 29.89 min [AS]; $p = 0.0001$, Fig. 1). There was no conversion of LA to an open appendectomy during the observation period in either group. The overall incidence of intraoperative complications was low (0.9 %) and showed no significant differences between RS and AS (1.02 % [RS] vs. 0.8 s% [AS]; $p = 0.6$).

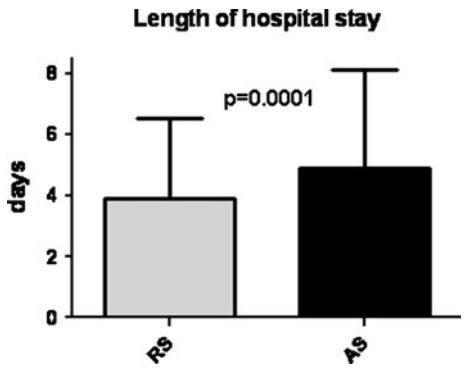

Fig. 2 The length of the hospital stay after laparoscopic appendectomy in patients treated by resident surgeons (RS) versus attending surgeons (AS)

Postoperative course

The duration of the hospital stay was shorter for patients treated by RS compared to those treated by AS (3.92 ± 2.61 days [RS] vs. 4.87 ± 3.23 days [AS]; $p = 0.0001$, Fig. 2). The overall 30-day morbidity was low (2.6 %, Table 2) including surgical site infections, incisional hernia, pleural effusion, postoperative ileus, stroke, arrhythmia and allergic reaction. The 30-day morbidity was higher in patients treated by AS compared to RS (1.8 % [RS] vs. 3.7 % [AS]; $p = 0.04$). Surgical reinterventions were necessary in 1.4 % of all patients, with a lower rate in patients

Table 2 Postoperative surgical reinterventions and the 30-day morbidity rate in patients treated by resident surgeons (RS) versus attending surgeons (AS)

	Treated by RS	Treated by AS
Surgical reintervention	4 (0.6 %)*	13 (2.5 %)*
Surgical site infection	5 (0.7 %)	9 (1.8 %)
Postoperative ileus	3 (0.44 %)	2 (0.4 %)
Incisional hernia	1 (0.15 %)	1 (0.2 %)
Pleural effusion	1 (0.15 %)	1 (0.2 %)
Arrhythmia	1 (0.15 %)	1 (0.2 %)
Stroke	0	1 (0.2 %)
Allergic reaction	0	1 (0.2 %)

* $p = 0.05$

treated by RS (0.6 % [RS] vs. 2.5 % [AS]; $p = 0.005$). There was no postoperative in-hospital mortality.

Discussion

Our study shows that LA can be performed by RS with low rates of intraoperative and postoperative complications. The fact that there was no conversion to OA during the last 11 years clearly demonstrates that LA is suitable as a teaching operation under appropriate supervision.

In our study, the duration of the operation was longer in teaching operations performed by RS, in agreement with what was shown in a previous report [5]. Jaffer et al. [6] showed that there was a decrease of the duration of the operation during the first 30 LA performed by young surgeons. Because of the regular rotations of our RS, we had a high rate of second year (and, therefore, inexperienced) RS during the observation period. Thus, the previously described decrease in the duration of the operation during the learning curve was not seen in our study.

The rate of intraoperative complications with 0.9 %, which was low compared to the literature. Furthermore, there were no conversions to open surgery during the observation period, which is significantly less than the previously reported conversion rates of 2–16 % [2, 5, 8, 15]. This might be explained by the fact that all teaching procedures were overseen by an experienced laparoscopic surgeon, and, therefore, intraoperative complications with the potential to lead to conversions could be avoided. To improve the technical skills of young surgeons and to avoid frequently made technical mistakes during the learning curve, the presence of an experienced surgeon might help to overcome the intraoperative misconceptions of the residents [13].

The overall 30-day postoperative morbidity in our series was low, at 2.6 %, and was comparable to that in previous reports [16, 17]. Infectious complications are the most commonly reported postoperative complications following a LA [5, 15, 16]. Despite using a laparoscopic bag to remove the appendix, irrigation of the abdominal cavity and the preoperative use of antibiotics, infectious complications remain a problem associated with appendicitis, and have to be accepted as integral part of the disease [3].

Patients treated by AS showed a twofold higher rate of postoperative morbidity compared to patients treated by RS. In comparison to other studies with morbidity rates up to 30 % [2, 16, 17], our morbidity rate of 2.6 % was low. Because of the retrospective nature of this study, there was a selection bias between the groups treated by RS or AS, since patients in poor general condition and with concomitant diseases were selected for the treatment by AS. In addition to the surgical experience of the resident, the general condition, age of the patient, as well as the ASA score and BMI of the patient, influenced the decision of whether they qualified for a teaching operation. Additionally, patients with complicated appendicitis were more often, but not exclusively, treated by AS.

Overall, the patients treated by AS had to stay 1 day longer in the hospital than patients treated by RS. Although the difference was significant, the clinical relevance remains indistinct, because this result is a consequence of the selection bias mentioned above. Compared to other countries, the length of hospital stay in our study was longer than reported in the literature [2, 3, 5, 17]. As was described previously [15] this is not only due to the patient's general condition, but also reflects specific features of the Swiss health care system [18]. Additionally, patients with complicated appendicitis were treated with intravenous antibiotics for 1 week postoperatively in the hospital, further explaining the prolonged hospital stay. This treatment strategy was previously described by Tuggle [19], who indicated that it was associated with a prolongation of the hospital stay.

The overall rate of reinterventions because of bleeding, intraabdominal infections or incisional hernia was low (1.4 %) in all patients, and was comparable to other retrospective studies, which had rates up to 4 % [15, 20]. The higher rate of reinterventions in patients treated by AS compared to RS in our study was probably due to the higher ASA scores and higher rate of complicated appendicitis in this patient collective.

The rate of OA was extremely low in our study compared to other reports [15, 17]. During the last few years, LA has become the treatment of choice in our hospital, and OA is applied only in children. This reflects our general policy to favor laparoscopic approaches wherever possible. Therefore, our young surgeons become confident in their laparoscopic skills at an early stage of their training, and adequate supervision of their developing laparoscopic

capabilities is always available to help ensure patient safety [21].

It has been shown, using laparoscopic cholecystectomy as an example, that even emergency procedures are suitable for teaching procedures [22]. All LA in the present series were performed as emergency procedures, and the RS were instructed by AS to establish a structured education even on nights and weekends. We have not yet discussed the costs of such a close control of the RS, but this will certainly be an issue for any teaching hospital [23].

There are a few limitations associated with this study that should be noted. This study was performed retrospectively without randomization concerning RS or AS treatment, or differentiation in surgical experience. Despite these limitations, we are convinced that our analysis demonstrates that LA is safe as a teaching procedure in the hands of RS.

In summary, this report of a series of laparoscopic appendectomies performed in a Swiss community hospital demonstrates that laparoscopic appendectomy can be performed safely, with low morbidity and no conversion, by resident surgeons under appropriate surveillance by attending surgeons.

Conflict of interest Drs. René Fahrner and Othmar Schöb have no conflicts of interest or financial ties to disclose.

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