

# Laparoscopic Appendectomy Performed by Residents and Experienced Surgeons

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## ABSTRACT

**Background:** Laparoscopic appendectomy is widely performed by surgical residents, but its changing indications and outcomes have been poorly investigated. The aim of this study was to examine whether a difference exists in indications and outcomes between laparoscopic appendectomies performed by residents and those performed by experienced surgeons.

**Methods:** Between 1999 and 2007, 218 laparoscopic appendectomies were performed and recorded. Data were analyzed to compare operations performed by residents with those by experienced surgeons in terms of indications for surgery and severity of disease. Moreover, laparoscopic appendectomies were thoroughly compared regarding outcomes and complications.

**Results:** The residents had fewer conversions with laparoscopic appendectomy (8% vs 17%,  $P=0.04$ ), and similar complication rates (12% vs 13%,  $P=0.16$ ), compared with experienced surgeons. The median operating time was also comparable (67 minutes vs 60 minutes,  $P=0.23$ ). However, patients operated on by residents had more emergencies (86% vs 70%,  $P=0.009$ ), included more foreigners (27% vs 15%,  $P=0.03$ ), and had intermediate to severe diseases, (81 vs 52%,  $P<0.001$ ) than patients did operated on by experienced surgeons.

**Conclusions:** Surgical residents performed more emergency laparoscopic appendectomies on foreign patients suffering from intermediate to severe diseases compared with experienced surgeons, with comparable surgical outcomes and lower conversion rates.

**Key Words:** Laparoscopic appendectomy, Residents, Safety, Trainees, Indications.

## INTRODUCTION

Traditional laparotomic appendectomy has always been an essential part of the surgical resident training program. However, worldwide introduction of laparoscopic appendectomy (LA) in the early nineties has renewed the interest of many staff surgeons in this technique, due to its excellent results, better patient cosmesis, the possibility of exploring adnexals in young women, and ultimately due to socioeconomic appeal.

Although patients undergoing LA have a shorter postoperative stay, fewer wound complications, reduced need of analgesic drugs, and are expected to return to normal activities earlier compared with those undergoing open appendectomy (OA),<sup>1-3</sup> broad acceptance of this approach has not been achieved. According to the skeptics, most of the theoretical advantages of LA are of limited clinical relevance or preponderant in young females and obese patients only.<sup>4-8</sup> The main concerns among surgeons include technical challenges, longer operating times, extra costs of laparoscopic equipment, and the potential for unexpected complications.<sup>4,9-12</sup> However, some regional European institutions, despite lack of conclusive data, reported increased rates of LA with excellent results after subspecialization.<sup>13</sup>

Moreover, unexpected low rates of laparoscopic appendectomies at teaching (university and affiliated) institutions raises the problem of appropriate resident training.<sup>14-18</sup> Others however are encouraged by optimal and cost-effective LA techniques for surgical residents,<sup>19,20</sup> or advocate LA as an ideal model for learning the skills for more advanced laparoscopic operations.<sup>21,22</sup> Undoubtedly, LA offers special challenges during training in the operating room, because the supervising surgeon has less opportunity to manipulate the ongoing procedure compared with the OA, including the issue of efficacious communication.<sup>23</sup>

Our aim was to compare the indications for surgery and

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the specific outcomes of LAs performed by surgical residents (SR) during their hands-on training with those performed by experienced surgeons (ES).

## PATIENTS AND METHODS

From January 1999 to December 2007, data from 474 consecutive, unselected patients who underwent an appendectomy (open or laparoscopic) at our institution were prospectively collected from the operating room database. We identified and thoroughly analyzed 218 (46%) LAs. The setting was the third Division of General and Oncologic Surgery of the Main University and Regional Hospital of Florence, Italy. Children under 16 years old are treated in another dedicated hospital. Staff surgeons are currently involved in resident education and training, including general and oncologic surgery, emergency procedures, laparoscopy, and transplantation. On-call duty is generally scheduled as one 24-hour-day shift every 3 days alternating with 2 other surgical divisions. Operations performed at night were considered those performed between 8:00PM to 8:00am

The decision to operate was up to the individual surgeon and was always based on clinical and laboratory tests (leukocytosis). Sonography was performed in young women to exclude gynecologic diseases, while other investigations (CT-scan or flexible endoscopy) were done in select cases. Emergency appendectomies were defined as those carried out within 12 hours after admittance to the emergency department. All patients were given an informed written consent module to read and sign before the operation, including detailed explanations of both advantages and disadvantages of laparoscopy.

Laparoscopy was chosen on an individual basis, based either on the preference of the operating surgeon (SR or ES) or on patient expectations. At our institution, residents begin by learning camera movements and port insertion and proceed with tissue dissection to perform the entire procedure. However, only the operations carried out entirely by the residents (without direct manipulations by the supervising surgeon, if any) were included in the SR group.

Demographics and perioperative parameters of all LAs were collected and subsequently analyzed after the identification of 2 different groups (group 1: SR - operations performed by surgical residents, and group 2: ES – those performed by experienced surgeons). Patients were discharged by surgeons on ward duty, rarely the same who

performed or supervised the operation. Outpatient clinic visits were scheduled after 1 and 4 weeks postoperatively.

Results and complications of LA along with other data were compared. Conversions to open appendectomy (through the classic Mc Burney or inferior midline incision in case of very challenging situations) were finally included as laparoscopies, for an “intention to treat” purpose.

Data were collected electronically, analyzed and compared between the SR and ES groups, by using the Statistical Package for the Social Sciences (SPSS version 13; SPSS Inc. Chicago, Illinois, USA). Descriptive statistics (median with range and frequencies) were used to summarize variables. The nonparametric Mann-Whitney test was used to compare the differences between groups and continuous variables, and the chi-square test (with exact corrections) was used when dealing with categories. A 2-sided P value <0.05 was considered statistically significant.

## Laparoscopic Technique

Prophylactic intravenous cefotetan (2g) and antithrombotic therapy were given routinely prior to the operation. Antibiotics were continued postoperatively according to the operative findings. General anesthesia was applied, using benzodiazepine for sedation, propofol for induction, and sevoflurane to maintain anesthesia. Pancuronium was used for muscle relaxation. A bladder drain was routinely inserted to avoid injuries during suprapubic trocar insertion, whereas nasogastric suction was used on an individual basis (generally removed after the operation).

The patients were supine, with 3 inserted trocars, the first done in the open manner, which has been done on a routine basis since 2003. The appendiceal stump and artery were normally secured and divided by an endoscopic stapler (Endopath 35 Articulated ATW 35 Johnson & Johnson, Ohio, USA), because of its easy application, particularly for residents, and guarantee of safety for gangrenous and very inflamed appendixes. Only in case of a “negative” appendix or subacute appendicitis was the stump tied by means of an endoloop. Bipolar diathermy was sometimes used to divide the appendiceal artery according to individual preferences. Suction drains were left in case of severe contamination, and withdrawn 24 hours to 48 hours afterwards. Intravenous antibiotic therapy was prolonged (including metronidazole and third-generation cephalosporin) for an additional 6 days depending on the operative findings. Standard postoperative

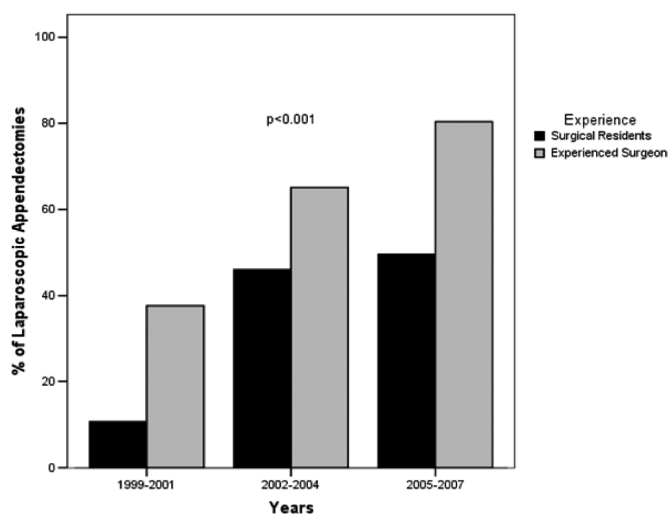
analgesic therapy included intravenous and oral acetaminophen.

## RESULTS

We recorded 218 LAs, and 91 (42%) were performed entirely by SR as the first surgeon. The percentages of LAs done by SR and ES are shown **Figure 1**. A statistically significant ( $P < 0.001$ ) increase in LAs performed by SR was observed.

The patient data comparing LA performed by SR and ES are shown in **Table 1**. Age, sex, and ASA scores were well matched between the 2 groups, while the proportion of non-Italian patients and emergency operations were higher in the SR than the ES group (27% vs 15%,  $P = 0.03$  and 86% vs 70%  $P = 0.009$ , respectively). SR operated on more cases of appendicitis with intermediate to high severity (edematous, phlegmonous, or gangrenous) (81% vs 52%,  $P < 0.001$ ), while ES operated on more subacute or complicated cases of appendicitis (perforated, abscess, peritonitis). The proportions of retrocecal position of the appendix (known to be a challenge for both open and laparoscopic procedures), drain left in place, and additional operations (ovariotomy, salpingectomy, or cholecystectomy for unexpected or concomitant diseases) were equal. The overall conversion rate was lower among SR (8% vs. 17%,  $P = 0.04$ ). Nevertheless, the median duration of surgery was similar between SR and ES (67 minutes vs 60 minutes,  $P = 0.23$ ).

When considering the perioperative complications, no deaths or major incidents were recorded in the whole



**Figure 1.** The cumulative percentages of laparoscopic appendectomies done by surgical residents and experienced surgeons.

series, excluding one SR operated patient, who experienced pulmonary ingestion caused by incorrect intubation. One intraabdominal collection was diagnosed in the SR group (requiring readmission) and 2 in the ES group, while wound infections were found only in patients converted to open surgery. One minor postoperative bleeding incident (no transfusion or reoperation needed) was experienced by a patient in the SR group. Other complications included pneumonia, urinary retention, transient atrial fibrillation, and postoperative nausea or vomiting. In conclusion, the overall complication rates and hospital stay were equal between the 2 groups. A summary of perioperative outcomes and complications is shown in **Table 2**.

## DISCUSSION

Introduction of new techniques into the surgical residents training program should always be monitored to guarantee patient safety and proficiency of the trainees. Results of this study suggest that the safety and efficacy of LA was the same in the hands of both residents and staff surgeons. Nevertheless, this study has the original bias of not being randomized or blinded. However, it is theoretically very unlikely to design a prospective controlled randomized trial to compare any surgical operation performed by residents as opposed to experienced surgeons, due to ethical, economic, and realistic issues.<sup>24,25</sup>

In the present study, we found, first of all, a significant increase in the number of LA for both SR and ES over the years, consistent with previous reports from similar teaching institutions.<sup>20,26</sup> However, the implementation of LA rates was higher among SR rather than ES. These final proportions seem to be similar to those reported in some American and European surveys, including both teaching and academic hospitals,<sup>14-17,27</sup> but inferior to others,<sup>22,28</sup> this reflecting a great heterogeneity among the institutions. Secondly, we found that LAs included more female patients, and ASA scores 1 and 2, at our institution, as reported by others.<sup>8</sup> This is partially supported by other randomized, controlled trials that found that laparoscopy performed in select patients with nonspecific or chronic abdominal pain increased diagnosis, shortened hospital stay, and reduced pain.<sup>29,30</sup>

Furthermore, the SR group performed an overall higher proportion of emergency surgeries. In our study, the proportion of LAs during the night did not reach statistical significance between SR and ES (more than 30% in both groups). Interestingly, in another study,<sup>20</sup> only 2% of the operations were carried out at night, this sup-

**Table 1.**

Comparison Between Laparoscopic Appendectomies Performed by Surgical Residents (SR) and Experienced Surgeons (ES): Patient Characteristics and Operative Reports

Characteristic	SR (n = 91)	ES (n = 127)	P Value
Age (years)*	33 (15–90)	30 (12–81)	0.99
Sex (F/M)	60/31	81/46	0.77
ASA† status 1–2/3–4	77/14	101/26	0.37
Foreigners (%)	25 (27)	19 (15)	0.03 <sup>‡</sup>
Emergency (%)	78 (86)	89 (70)	0.009 <sup>‡</sup>
At night (%)	41 (45)	43 (34)	0.12
Grade of appendicitis			<0.001 <sup>‡</sup>
Subacute/chronic/incidental	7 (8)	30 (24)	
Edematous/Phlegmonous	64 (70)	62 (48)	
Gangrenous	10 (11)	5 (4)	
Perforated/abscess/peritonitis	10 (11)	30 (24)	
Retrocecal (%)	5 (5)	15 (12)	0.15
Conversions (%)	7 (8)	22 (17)	0.04 <sup>‡</sup>
Additional procedures (%)	6 (7)	6 (5)	0.56
Drainage (%)	13 (14)	28 (22)	0.16
Operative time (minutes)*	67 (30–110)	60 (25–130)	0.23

\*Expressed as median and range; †P&lt;0.05.

‡ASA = American Society of Anesthesiologists.

**Table 2.**

Comparison Between Laparoscopic Appendectomies Performed by Surgical Residents (SR) and Experienced Surgeons (ES): Outcomes and Complications

	SR (n = 91)	ES (n = 127)	P Value
Bleeding (%)	1 (1)	0 (0)	0.42
Wound complication (%)	3 (3)	4 (3)	0.29
Abscess (%)	1 (1)	2 (1.5)	0.42
Other complications (%)	6 (7)	11 (9)	0.18
Pneumonia	1	3	
Atrial fibrillation	0	1	
PONV*	3	4	
Urinary retention	2	3	
Overall complications (%)	11 (12)	17 (13)	0.17
Hospital stay, (days)†	4 (2–13)	4 (2–14)	0.64
Readmissions (%)	1 (1)	0 (0)	0.42

\*PONV=Postoperative nausea and vomiting.

†Expressed as median and range, P&lt;0.05.

porting the differences in patient selection between 8:00 P.M. to 8:00 A.M.

The issue of correct indications and timing for surgery is controversial, and a preoperative assessment of complicated (perforated or gangrenous) appendicitis has been poor in recent years. An up-to-date long-time series showed, unexpectedly, stable rates of perforation, in spite of an overall concomitant increase in appendectomies, probably due to the increased use of laparoscopies and CT scans.<sup>31</sup> Similarly, this survey found no relation between “negative” appendectomies and perforation rates, that could justify conservative management (antibiotic therapy) for initially nonperforated cases. Moreover, delaying appendectomy for 12 hours to 24 hours after presentation does not significantly increase perforations, operative times, or length of stay<sup>32</sup> as opposed to another study that reached the opposite conclusion, with increasing rates of complications achieved delaying operations.<sup>33</sup>

In the present study, the relative proportions of a subgroup of patients with a doubtful diagnosis (incidental, elective, or subacute appendicitis) were acceptable and comparable to findings in a recent review.<sup>34</sup> However, the SR group had fewer doubtful diagnoses (8% vs 24%) and more very complicated cases of appendicitis (perforated, abscesses, peritonitis) (11% vs 24%) with half the number of conversions (8% vs 17%) with respect to ES. This may reflect different patient selection.

At our institution, residents are expected to be more involved in emergency cases, while staff surgeons operate on more patients who require LA for subacute, incidental, or elective diseases, but might become the attending surgeon in very difficult emergent cases, such as those with perforation, abscesses, and peritonitis, thus explaining the higher percentage of conversions in their group. Others have hypothesized that laparoscopy could have increased the negative appendectomy rates, although removing a “normal” appendix continues to be encouraged.<sup>26</sup>

The SR group performed LA on more foreigners (non-Italian citizens) than the ES group did (27% vs 15%). Another study found that racial disparities and privately insured patients played a role in the decision to approach appendicitis with laparoscopy in New York State.<sup>35</sup> Although the Italian Health System and racial composition of the population are very different from that in North American, the aforementioned factors could have influenced our study as well, foreigners being mostly admitted during the night and in an emergent setting and almost never in an elective subacute condition.

Other confounding factors that probably had a role in patient selection and the choice of laparoscopic surgery include residents’ seniority and the attitude of individual experienced surgeons.<sup>36</sup> But the above 2 factors were not considered in the final data analysis, although a study from Taiwan showed no differences in the main outcome of LA performed by trainees with different levels of experience.<sup>21</sup>

Interestingly enough, SR had comparable operating times (67 minutes vs 60 minutes) with respect to ES in our study. Although training simulators were available at our institution, our SR had no structured training on dummies or animal models, as developed in some centers.<sup>37,38</sup> The safety of LA performed by residents without animal experimentation or virtual reality simulations has been reported to be comparable in terms of complications, but requiring either longer<sup>39</sup> or similar<sup>40</sup> operating times. However, at our institution the SR were never formally “unsupervised,” because an experienced surgeon was always present in the operating room. Comparable operating times between SR and ES is an important issue for those who discourage teaching LA to trainees because of financial and management problems.<sup>9,10,16</sup> Inexpensive simulations of LA for SR could probably help in the standardization of operating times in teaching environments.<sup>37</sup>

Moreover, we did not have any major incidents or deaths with the exception of pulmonary ingestion caused by incorrect intubation. No specific complications resulting from laparoscopy were observed. The most potentially important recognized complication of LA is the development of intrabdominal collections,<sup>4,9,10</sup> but this was observed in less than 2% of the patients in our study and was not statistically significant between SR and ES. Results from other teaching environments report few complications and short postoperative stays.<sup>20,21</sup> Wound infection rate (3%) was found to be equal in both SR and ES groups and essentially correlated to patients who required conversion to open surgery.

## CONCLUSION

Even when indications for laparoscopic appendectomy are different between residents, who performed it mostly in emergent and intermediate to severe acute appendicitis, and experienced surgeons, who did it primarily in elective subacute conditions, outcomes and operative times were not significantly different. We can, therefore, conclude that in the present retrospective comparative study, LA was found to be a safe and indicated operation in the hands of surgical residents in every emergent case.

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