Tech Coloproctol (2011) 15:1–6
DOI 10.1007/s10151-010-0656-2

REVIEW

A brief review of laparoscopic appendectomy: the issues and the evidence

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Received: 7 April 2010 / Accepted: 28 October 2010 / Published online: 18 November 2010
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Abstract Laparoscopic appendectomy was first performed more than 25 years ago. We performed a systematic literature search on laparoscopic appendectomy and selected related topics. The technique should be considered the gold standard for surgical removal of the appendix in women of childbearing age (level of evidence Ia). There is minor but consistent evidence that it should also be advocated for men (level of evidence III), obese (level of evidence III), and elderly (level of evidence IIb) patients, while there is some evidence of unfavorable results on pregnant women (level of evidence IIb). Studies reporting higher incidence of intra-abdominal abscesses after laparoscopic appendectomy are difficult to interpret due to a lack of standardization of the operative technique and lack of uniformity related to the different grades of disease (ranging from uninflamed appendix to diffuse peritonitis, gangrene, or perforation of the organ). As far as surgical technique, the three-port procedure is superior to needlescopy and single port access (level of evidence Ia). Costly high-tech instruments for dissection are mostly unnecessary (level Ib). Mechanical closure of the stump might prove safer (level Ib). The quantity of peritoneal lavage fluid is generally scanty (level III), and abdominal drains are not useful (level Ia). Fast-track protocols should be implemented (level Ic). Training and technical standardization are the key to devising future trials on this topic.

Keywords Laparoscopic appendectomy · Complications · Technique

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Introduction

There is still controversy about the technical aspects and outcomes of laparoscopic appendectomy (LA), over 25 years after Kurt Semm first described the operation [1]. The main questions regarding laparoscopic appendectomy today involve the indications, outcomes, surgical technique, surgical conduct for "innocent appendix" during explorative laparoscopy, and learning curve. More than a thousand articles, almost 60 randomized controlled trials (RCT) and at least 10 meta-analyses, have been published. A survey of papers regarding the most common laparoscopic procedures (all accounting for similar numbers of cases both in central and district hospitals), indexed in Pubmed from 1985 up to 2010, gives an idea of the diffusion of the techniques (Fig. 1). A plateau was reached by trials on laparoscopic cholecystectomy in the nineties, after its wide diffusion due to early validation as the "gold standard" for surgical treatment of cholelithiasis. The frequency of other studies regarding more technically difficult operations (laparoscopic ventral hernia repair, laparoscopic colectomies) is still increasing, which is true also for LA. These data reflect an ongoing, but still incomplete, acceptance of these techniques by the surgical community.

Indeed, as pointed out in a recent review [2], most of the studies in the literature have pitfalls and lack consistent

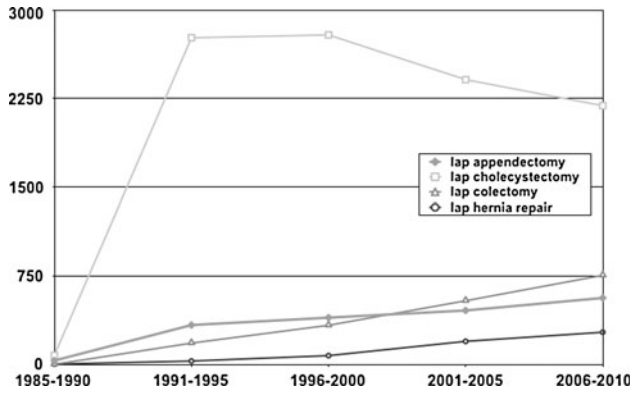

Fig. 1 Number of Pubmed publications regarding different laparoscopic procedures in the last 25 years

findings that can serve as a basis for recommendations (Table 1). This fact is underlined by a paper concerning statistical methodology in which a RCT on LA versus open appendectomy (OA) is cited as an example of errors at assessing power and sample size [3]. Furthermore, there is a discrepancy between the "real world of appendicitis" and the clinical environment in which controlled trials comparing LA and OA had been performed [4].

Methods

We carried out an online search using the keyword "laparoscopic appendectomy" in Pubmed, Embase, and Google Scholar. A total of 68 articles including all RCT were included. Since some topics were not investigated in these level I-II studies, 42 retrospective and case series were specifically selected based on the quality of the trial (favoring the most recent, those with the most patients, those with the best study designs and the multicentric studies). The guidelines published by the European Association of Endoscopic Surgeons (EAES) [5], by the Society for Surgery of the Alimentary Tract (SSAT) [6], and by the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) [7] were also examined. Levels of evidence as stated by the Oxford classification are outlined in Table 2.

Table 1 Pitfalls of RCT's data for clinical recommendations

Clinical problems	Trials with specification (%)	Data for evidence	Criticality
Surgeons' expertise	15.8	No	Differences in OA (expertize in 100% of the surgeons) and LA (sometimes one or few surgeons, mostly not specified)
Antibiotic therapy	68.4	No	Only preoperatory. No standardization
Complications	100	Scarce	Undefined "minor vs. major" or "specific vs. unspecific"
Normal appendix left in situ	23.7	No	Same behavior not followed for OA
Blinding of post-op recovery	13.2	No	Only partially blinded
Operative time	100	Sufficient	No standardization for LA technique with wide range
Cosmesis	5.3	No	Questionable to test patient's judgement of cosmesis only few days after operation
Defined primary outcome	33	Scarce	Mostly exploratory studies
Defined power and sample	23.7	Scarce	Number of recruited patients needs calculation on the basis of the primary outcome for fixed type I errors

Data extrapolated from: Kapische et al. (Surg Endosc 2006; 20:1060–10608)

Table 2 Oxford classification of the levels of evidence for therapy, prevention, etiology

Level of evidence	Grading criteria	Grade of recommendation
1a	Systematic review of RCTs including meta-analysis	A
1b	Individual RCT with narrow confidence interval	A
1c	All and none studies	B
2a	Systematic review of cohort studies	B
2b	Individual cohort study and low quality RCT	B
2c	Outcome research study	C
3a	Systematic review of case–control studies	C
3b	Individual case–control study	C
4	Case series, poor quality cohort, and case–control studies	C
5	Expert opinion	D

Results

The Cochrane Foundation meta-analysis on LA vs. OA [8] collected data from 54 RCTs and raised the following issues: LA carried a three-fold increase in the incidence of intra-abdominal abscesses and a similar decrease in wound infections, a significant reduction in negative appendectomies, postoperative pain, length of hospital stay, time until return to normal activity, and outside hospital costs, despite higher operative times and costs. In conclusion, the authors recommended LA for fertile women, obese, and employed patients. Similar results were obtained by a German health technology assessment study group, which considered LA "reasonable" in young women because of a decrease in negative appendectomy rates (if left in situ after laparoscopic exploration), better quality of life and cosmesis, early refeeding, stool passage, and lower length of hospital stay. The conclusion does not favor one or the other technique leaving the decision "to the physicians individually" [9]. In 2009, the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES), compiled guidelines for LA in which the transition toward mini-invasiveness is advocated [7]. In fact, despite level Ia evidence that remains limited to fertile women, several other patient groups benefit from LA at a level II evidence: those with complicated appendicitis, the elderly, the obese, and the pregnant patients.

Few studies evaluate infectious complications in complicated appendicitis. An interesting database collection of a large case-matched group of patients presented at the 2009 American Society of Colon and Rectal Surgeons (ASCRS) meeting showed that LA was associated with a lower grade of overall and surgical site infections, but a higher incidence of intra-abdominal abscesses in LA (6.2% vs. 4.1%) (level IIb) [10]. The authors suggested a careful and vigorous irrigation extended to all the peritoneal spaces, including the bowel loop area. A recent alert from the American College of Surgeons [11] warns that treating appendicitis by laparoscopic surgery may not be worth the cost; analysis shows that the newer method results in high costs and increased complications. Despite this, there is a trend toward mini-invasiveness in all fields, also because surgeons are becoming better acquainted with this mode of access. A distinction must be made between types of complications, using Clavien's classification [12]. According to these criteria, LA is correlated with increase in grade 3 morbidity, since intra-abdominal abscess might require percutaneous drainage, reoperation or right hemicolectomy in the worst cases (in contrast OA carries a minor increase in grade 1 morbidity). Elderly and obese patients, the categories in which overall complications are higher (especially those related to postoperative impairment of pulmonary function and resumption of normal activity), seem to be the sub-groups, which would benefit from laparoscopy (evidence level II–III) [13, 14].

As far as pregnant patients, a review article from the United States [15] concludes that fetal risk in LA does not increase significantly (level II evidence). Albeit, this conclusion is opposite to that of another English review of the topic [16], published in the same year. This should suggest caution when considering LA as the gold standard in pregnancy.

Normal appendix: to remove or not to remove

SSAT guidelines [6], published in 2006, recommend the removal of a normal appendix in the absence of other significant pathology at exploration. This point of view is shared by the majority of authors and is based on these facts: the relatively low rate of complications due to surgery, the significant number of "endoappendicitis" (macroscopically normal aspect of the serosa with an inflammation of the inner layers seen at histology), which varies from 11 to 26%, as well as the percentage of reoperations (6%) for the same symptoms in those patients whose appendix was left in situ [17] (evidence level IIIb). If this recommendation was to be standardized, the rate of negative appendectomies would not fall after laparoscopic exploration, thus nullifying one of the advantages of LA when compared to OA. Moreover, complication rate is indeed very low but not zero, and non-surgical therapy may resolve up to 50% of cases [18, 19]. Treatment in these cases should not therefore be standardized, but evaluated on a case-to-case basis.

Surgical technique standardization

Technique standardization has been introduced in the SAGES guidelines as a means of reducing the pitfalls of this operation. In fact, retrospective and cohort studies have demonstrated a reduction in operative time, conversion rate, morbidity, and surgeon satisfaction in training centers where a standardized method is used and taught [20, 21] (level IIb). Lack of standardization may also make it difficult when comparing different studies in the literature, since the various procedures used to dissect, close the stump, wash the peritoneum, or markedly differ in trocar positioning, which all may lead to different results. The level of evidence regarding the technical aspects of LA is quite low and based principally on consensus statements and a few limited RCTs.

Trocars: access, number and position

Access to the peritoneum is generally performed through an umbilical incision, either by means of "open" access or

by a Verress needle and a "closed" technique. Different groups choose one or the other approach based on their standard practice in laparoscopy. Once pneumoperitoneum is established another two trocars are required, in order to obtain the proper triangulation: lower left quadrant (LLQ) and suprapubic, LLQ and lower right quadrant (LRQ), suprapubic and LRQ, or both trocars in the suprapubic position (the latter one is particularly appreciated for cosmetic reasons since scars are hidden in pubic hair). Whether a cranio-caudal or a caudo-cranial view is preferred depends on the surgeons choice and habits. Care must be taken to avoid injuring the inferior epigastric vessels. The number of trocars can be limited to two by using transabdominal threads passed through the top of the appendix (puppeteer's technique) [22, 23]. Single-port appendectomy (SPA) deserves particular mention, as it foreshadows natural orifice surgery and might have a rapid spread in the near future. At present, there is only one retrospective study comparing SPA to LA, which seems to outline some advantages in terms of cosmetic results and patient satisfaction [24]. The technique is not particularly difficult, and the ease of access should result in success (in contrast to endoscopic access, natural orifice surgery, which is much more dangerous [25], is still experimental and requires specific instruments), as soon as some category of patients (young women and men) shall clamor for a surgery "without scars" [26]. Needleoscopy (the use of 3-mm instruments and a 5-mm optic) has been suggested as an improvement of minimal invasiveness, but a systematic review of RCTs evidences a similar morbidity together with a higher conversion rate and operative time [27] (level Ia).

Treatment of the mesoappendix

New ultrasonic or electrothermal dissection devices have been proposed for dissection of the mesoappendix, but although there is a reduction in operative time (41 vs. 54 min) and conversion rates (9.4 vs. 11.1%) in a single RCT [28], the costs do not seem to outweigh the benefits.

Appendiceal stump closure

A similar argument can be made for the stump closure. The use of routine stapling seems to be associated with certain advantages: a reduction in postoperative infection, simplicity of usage, even by residents and at night-time, and a lower operative time. The disadvantages are a higher cost (compared to endoloop) and the obligatory use of a 12-mm trocar [29] (level Ib). A protocol recruitment is now underway to establish, once and for all, whether the incidence rate of intraabdominal abscesses can be lowered by using routine stapling. This could effectively change the surgeon's habit of using endoloops [30], even though a recent review does not report a significant difference between the two methods, apart from operative time [31].

Peritoneal washing

Peritoneal lavage, when, how and where to do it, is a matter of debate. Two retrospective studies come to opposite conclusions to the question whether irrigation can diminish infectious intraabdominal complications after LA. One study favors copious lavage of the entire abdominal cavity, and the other sustains that aspiration is enough and that irrigation might otherwise contribute to the contamination of the abdomen, especially in appendicitis without generalized peritonitis [32, 33] (level III). The answer might lie in a small experimental study, conducted on children, that attempts to determine the quantity of saline solution needed to significantly lower bacterial concentration; for 5.8 l/m^2 of peritoneal surface (established 1.4 m^2 as median surface [34]) at least 8 l of saline solution [35] should be used. Such an extensive lavage is seldom made even in generalized peritonitis (it takes about 3 min for every liter of saline to be used without a peristaltic pump, and the time required is not compatible with the declared operative times, as lavage time should be half the entire time required for the operation).

Specimen extraction

The appendix can be extracted in different ways. The most common is the use of an endo-bag, which permits secure retrieval through a 10- to 12-mm port [36]. Some surgeons use alternative methods, cheaper and hand-made, like the adaptation of a surgical glove to act as a bag. The skeletonization of the mesoappendix permits, in cases of limited inflammation, extraction directly through the 10- to 12-mm port, which is a mean of continuing to keep the mesoappendix from touching the abdominal wall. The use of a stitch (Fisherman's technique [37]) is helpful whenever a larger volume of the organ hampers the passage of a grasper in case of a single 10-/12-mm port access to use for extraction. Even in SPA surgery, appropriate removal must be assured, and the type of multiport device used is therefore important for a correct operation, and it must guarantee a complete absence of contact between the appendix and the abdominal wall.

In fact, the reduced possibility of wound infection is one of the advantages of LA, and mixed techniques (i.e. laparo-assisted appendectomy), in which the organ is mobilized outside the abdomen and the appendectomy is performed in an open fashion through the port-incision, are associated with a higher rate of wound contamination (4.6% of infections in a Saudi Arabian retrospective review) [38].

To drain or not to drain

The use of drains is unnecessary and might also be harmful in some cases due to the potential development of cecal fistulae, as suggested by a large meta-analysis [39] (level Ia). Drains are usually placed in patients with diffuse peritonitis or localized abscess cavities, even if a thorough peritoneal lavage is thought to be sufficient protection against recurrent abscesses. The surgeon must be aware that hemorrhagic complications, which are rare but might occur in the immediate postoperative period (although the use of blunt tip trocars instead of bladed ones has dramatically reduced the number of these complications [40]), must be diagnosed indirectly by frequent monitoring of the patient. This argument is frequently used by those endorsing routine placement of a drain [41].

Postoperative protocols

As a last step in the evaluation of the possible advantages of LA compared to OA, we must cite the consistent progress that has been made in postoperative management. Many studies have emphasized the value of fast-track surgery, even though it is not yet used in most surgical units [42]. In the few papers that have analyzed fast-track surgery applied to OA, patients' hospital stay was approximately as short as that of patients who undergo LA [43] (level Ic). Fast-track colorectal surgery has not only improved outcomes after open procedures but also after laparoscopy, so that possible improvements of traditional appendectomy will not compete with the advantages of minimal invasiveness.

The training issue

A final word must be said regarding the training and learning curve in LA. Appendectomy has traditionally been regarded as a fundamental step in a junior surgeon's training. An analogous role must be claimed for LA, as it is fundamental for acquiring dexterity and skill in laparoscopy, necessary to tackle advanced minimally invasive operations [44]. Prospective studies on residents' outcomes in appendectomy operations have stated the learning curve is completed after twenty operations [45] (level III).

Conclusions

Laparoscopic appendectomy in adults has in recent years gained acceptance as the gold standard especially in subcategories of patients such as fertile women, working-class men, obese, and elderly patients. The method has proved valid both in uncomplicated and complicated disease. Undoubtedly, the supposed increase in the rate of intra-abdominal abscesses has not been denied by meta-analyses: this remains the main issue to be examined in the future. Answers might be obtained by means of high quality RCTs based on a fully standardized technique, which should comprehend adequate peritoneal lavage and a standard decision-making algorithm. Stump closure by mechanical stapler, still too expensive at present, may also reduce the risk of abscess formation. Moreover, a wider application of fast-track principles for laparoscopy might further improve the results. The few articles describing training results and the learning curve must be considered in light of the specific surgical context in which they are applied; differences arise between teaching and district hospitals, highly specialized units and emergency surgery wards, young and experienced surgeons, day and night-time shifts as well as previous experience in laparoscopy. It is our opinion that that future trials should consider these differences and focus on answering the questions for which there is still no adequate level of evidence. The point should no longer be whether LA is better than OA, but how to perform a correct laparoscopic appendectomy and in which situations it should be contraindicated.

Acknowledgments The authors thank Mrs. Janette Hanney for the linguistic support.

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